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A Case study of value streams and lean implementation for a small print shop

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A Case Study of Value Streams and Lean Implementation for a Small Print Shop

By Alexis Andra Austin

A thesis submitted in fulfillment of the requirements
for the degree of Master of Science
in the School of Media Sciences
in the College of Imaging Arts and Sciences
of the Rochester Institute of Technology

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Technical Advisor: Stephen Whittaker

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Abstract

The growing use of portable Internet devices (smart phones, iPads, laptops, etc.) has caused a huge shift toward digital distribution of content over traditional print processes. Poor economic conditions have contributed to increased customer price sensitivity and higher costs of goods involved in printing. These factors have changed demand for traditional printed products. Many printers have been unable to adapt to the new market environment, leading to dwindling profit margins and thousands of shop closures.

Many strategies have been touted as the “best” way to stay profitable in the new market environment, including value-added services, new machinery, and software packages. However, according to the NAPL, productivity improvements, such as Lean, will now play the central role in differentiating the leaders in the industry.

Printers, particularly small- and medium-sized printers, have been slow in their adoption of Lean or any of its variants. Lean organizations produce less waste (in its many forms), have improved product quality with shorter lead times, and have employees who are more engaged. Unfortunately small- and medium-sized printers are less likely to begin productivity improvement initiatives due to lack of knowledge, time commitment issues, fear of change, and lack of resources.

The goal of this case study is to provide a theoretical framework and an in-depth example of how a small print shop’s production line operates and how to generate a tailored action plan for implementing Lean Manufacturing Principles. Specifically, the study focuses on the creation and usefulness of value stream mapping (graphically identifying the many forms of waste within a given system) for a small print shop. The case study is written with

an easy to follow language as a guide to aide other small printers in creating their own Lean implementation plans.

Careful, direct observation and documentation of a small 6-employee print shop occurred over a short period to gather data about the shop's current value stream. Three product families were chosen for mapping: digital color printing, digital black and white printing, and offset press. Data collection focused on the workflow for jobs from creation to completion, how long each step takes, and how communication and materials move through production. Current value stream maps were generated using the collected data and were used to develop ideal and future maps. Detailed analysis of the current value stream revealed six key areas for the company to address that will provide the greatest benefit toward becoming Lean. The areas are: company culture, organization, bottlenecks, scheduling, communication and inventory. The following recommendations were made for the company to reduce waste and excess costs, improve value-added ratios, and reduce stress on employees.

The current company culture has trust issues and does not encourage innovation. Management's constant commitment to building and maintaining a new culture will be essential to creating change. Daily meetings and Kaizen events can help establish trust and empower employees to find and implement solutions. The shop floor needs 5S organization and will also require the implementation of an inventory system and reduction initiative. New suppliers may need to be found to accomplish just-in-time delivery.

To alleviate bottlenecks in premedia and finishing, the graphic design stage should be removed from production to give production control the responsibilities of job scheduling and load leveling. Finishing then becomes the pacemaker process and dictates the flow, preventing push within the system. Kanban signals and supermarkets are recommended for maintaining a pull system. Communication across the shop can be improved through daily production meetings, utilizing exiting software for job tracking, establishing visual management boards, and establishing a sales department for handling customers.

Chapter 1

Introduction

Statement of the Problem

The growth in popularity of smart phones, tablet devices, laptops and other technologies that can connect to the internet from any location has lead to a huge shift toward the digital distribution of content over traditional print processes. Poor economic conditions have contributed to increased customer price sensitivity and higher costs of goods involved in printing (paper, ink, labor, etc). Economic factors and the growing focus on digital media have changed the demand for traditional print products, leaving printers in a difficult spot. Many printers have been unable to adapt to the new market environment, leading to dwindling profit margins and thousands of shop closures annually (Paparozzi & Vincenzino, 2012).

For those who remain, it will no longer be enough to carry on as usual. In recent years, new, faster, higher capacity equipment, various types of management software, and value-added services have all been touted as ways to provide customer value and remain profitable. However, according to the NAPL 2010 Strategic Perspective, these will not be enough. Productivity improvements, such as Lean, will now play the central role in differentiating the leaders in the industry.

Many companies have started using Lean or one of its variants, but printers, particularly small- and medium-sized printers, have been slow in their adoption. Large manufacturing companies have been quicker to adopt Lean and have seen great benefits. Lean organizations produce less waste (in its many forms), have improved product quality with shorter lead times, and have employees who are more engaged (Womack & Jones,

2003). Unfortunately small- and medium-sized printers are less likely to begin productivity improvement initiatives due to lack of knowledge, time commitment issues, fear of change, and lack of resources.

Examples and case studies of Lean manufacturing are available online, in books, and from paid consultants. However, few have been made publicly available on Lean implementation for a small printing firm. Although these case studies are available, many small businesses and printers in particular lack the knowledge to interpret the results and apply the principles within their own companies. The goal of this case study is to provide a theoretical framework and an in depth example of how Lean practices and value stream mapping can be applied to a small printer to improve production efficiency and reduce waste in order to remain profitable. This framework and methodology is thoroughly explained and documented in a way that hopefully provides a road map for others to follow.

Reason for Interest in the Study

Most companies can benefit from the introduction of Lean as an organizational tool for productivity improvement. At one point, the researcher spent time working in a small print shop as a graphic designer and pre-media assistant. While there, she learned the manufacturing process and saw many opportunities for improvement in every aspect of the business. The company appears to be representative of so many small print shops that desperately need change, but have no idea where to begin. When searching for a shop to study, the researcher was fortunate to eventually find a print shop that was willing to allow anonymous observation and was open to recommendations. This research is intended to help guide the observed shop, or any small printing company, through the difficult first stages of Lean implementation, particularly the creation of value stream mapping to identify areas most in need of change.

Chapter 2

Preliminary Literature Review

Status of the Printing Industry

The printing industry, like most other industries has felt the effects of the recent economic recession and is slow to recover. Sales have stagnated and on average printing companies have seen little overall growth since the industry hit it's bottom in 2010 (Paparozzi & Vincenzino, 2012). That's on average. According to the National Association for Printing Leadership (NAPL) Printing Business Panel, 10% of companies have seen growth this past year of at least 5%, while 6.9% have seen a decline of 20% or more. This profitability spread indicates large differences in business models among the printers on the panel. In addition to the lack of sales, costs have been continually increasing. The NAPL reported that "total costs have increased 3.5% so far [in 2012], driven by a 9.9% jump in the cost of goods sold" (Paparozzi & Vincenzino, 2012). The poor economy and many companys' inability to adapt to the new market environment have lead to record consolidation within the industry. Since 1998, over 10,000 printing firms, 28% of the total, have closed down or been bought out (Paparozzi & Vincenzino, 2012).

Despite the consolidation, competition is increasing. Over the last decade advancing technology, new management software, and the addition of new products and services have been promoted as solutions for struggling businesses. However, the persistent lack of growth suggests that performing triage by piling on new software, products, and services to the existing business structure is not enough. Firms are discovering the changing business environment is necessitating change in the fundamental ways of doing business. It is no longer viable to just continue what we've been doing and do it well.

The NAPL also surveyed its Panel of Businesses to learn their plans to improve sales and profitability in 2012. Over 80% of respondents indicated plans to improve and deepen relationships with clients to better serve their needs. Over 60% indicated plans to streamline workflow and production processes to improve efficiency and increase productivity using existing resources (Paparozi & Vincenzino, 2012).

Overview of Productivity

There are three popular methods for evaluating productivity, sales per employee, production employment, and throughput. Sales-per-employee is a popular method used in manufacturing industries that allows broad cross comparison between different firms and between firms in different manufacturing industries. The NAPL also uses a similar ratio called production employment that refers to how much product is produced for each chargeable hour of labor (Paparozi & Vincenzino, 2012). This ratio is more focused on production than the Sales Per Employee method, which is based solely on revenue, and therefore is a bit more helpful to production managers while still being good for economic cross comparison.

The third method for evaluating productivity is throughput. Throughput can be defined as “the total number [or dollar value] of saleable, completed and delivered jobs that the production workflow is capable of producing in a given period of time” (Millet & Rosenberg, 1992). Throughput is limited by bottlenecks, which are any operation that slows or hinders the production system. If the company is able to increase its output with the same fixed resources then it is considered to have increased its productivity, and vice versa (Millet & Rosenberg, 1992). Throughput capacity is specific to each company and therefore is a good metric for tracking productivity gains in-house, but is less applicable to economic comparisons.

Productivity Issues in the Printing Industry

With the constant evolution and innovation happening in the printing technology sector, the promise of ever-greater throughput is appetizing to printer's who do not understand that throughput is not the same as consumer demand. Throughput exists (or should exist) within a given system to satisfy consumer demand for products, but not exceed that demand. Excess throughput, or available manufacturing hours, becomes inventory if not consumed (sold) to the customer and is therefore a waste of resources. Many printers make large capital investments in new equipment that promise faster everything, but the equipment is not used to its full potential or more than needed is produced, wasting time, energy and resources (Dickeson, 2003, Millet & Rosenberg 1992). Unfortunately, in the printing industry, gauging the appropriate throughput is challenging because consumer demand is constantly fluctuating.

In addition to the belief that faster machines improve productivity, there is also a belief that automation is the key to productivity gains. Automation can increase productivity when strategically implemented at the bottlenecks within a system. Reduced bottlenecks bring actual output closer to throughput capacity, therefore improving productivity. However, investing in the automation of functions that exist outside these bottlenecks can have limited returns (Hoover, 2000). For example, automating plate adjustments will not reduce bottlenecks that happen at the graphic design or pre-media stage. Further, faster machines and automation are useless in the hands of a worker who is not trained to understand and utilize them (Bauer, 2005).

One of the largest contributors to lost productivity is waste in its many forms. As previously mentioned, both unmet production capacity for a piece of equipment and overproduction of products are forms of waste. Most people wouldn't immediately think of unused production capacity as waste, but it is a loss of the capital and space invested in the equipment during the time it is not being used to add value for the customer (Womack & Jones, 2003). Overproduction is more obviously wasteful in that you have a physical product

that will not be sold immediately and must consume time, labor and energy to be inventoried and stored. Other examples of waste on the production floor include poor job planning, ineffective scheduling, rework, disorganization, equipment downtime, work in progress, make-readies, clean-up—anything that does not add value to the final product is waste (Cooper, Keif & Macro Jr., 2007).

Current Organizational Tools For Productivity Improvement

Many organizational management solutions have come and gone, while others have morphed and changed to become those most commonly known today. It is important to distinguish the difference between an organizational system and the tools employed by those systems. Some systems actually use the same tools with different end goals or over-arching intentions, and those relevant to this study will be discussed later in this chapter. The four organizational systems most relevant to this printing industry case study are Six sigma, Theory of Constraints (TOC), ISO 9000, and Lean.

Six Sigma

The basic principle of Six Sigma is that reducing variation in a process will lead to reduced defects and therefore greater productivity and improved profit. Defects are determined by customer expectations. The term *six sigma* is derived from statistics and means “less than 3.4 defects per million, or a success rate of 99.9997 percent” (Weiner, 2004). Six Sigma is usually carried out by highly trained specialists, known as Black Belts, who conduct projects to identify causes of variation, then implement changes to reduce defects within the company (Sayer & Williams, 2012). These changes can save both large and small companies huge sums of money. Six sigma is less about creating a new culture where all employees are constantly looking for ways to improve, and is more about precise statistical analysis by a few specialists. The concept lends itself well to companies who perform highly standardized production; however, this

is not usually the case for a small print shop where mass-customization is dominant. It may be applicable to printers who have limited their services to a specific set of products that are performed using the same procedures every time, and although the graphic design of each job may change, the finished products are standardized and uniform.

Theory of Constraints (TOC)

The theory of constraints centers around finding the constraints or bottlenecks within a system, then setting the pace for production based on the speed allowed by the constraint. The constraint dictates the system's maximum capacity, not the potential capacity of other segments within the system. TOC is considered a continuous improvement approach where the goal is to constantly work toward improving the efficiency of the constraint to increase the overall efficiency (Rahman, 1998). This concept is relevant to small print companies where a small number of employees are performing multiple jobs and some of those jobs are more time consuming than others. For example, if all incoming files must be prepared for output by a single in-house designer, then the designer's speed dictates the pace of the shop's order input.

ISO 9000

ISO 9000 is a system of standards for quality management and quality assurance with quality defined by the end customer. Its primary goal is to reduce defects by creating effective work systems. Companies can go through an extensive and costly evaluation process (Clifford, 2005) to become certified as meeting the ISO 9000 standards (Kipphan, 2001). Although a fairly popular system, it has been criticized as being wasteful. These critics argue that the standards are more about conformance than improvement and act as sort of a contract that the customer can use to guarantee the quality of the product (Seddon, 2000). ISO 9000 can help businesses gain trust from potential clients, give employees a certification to be proud of, and help the company maintain its financial status. However, since it does not help the company

grow, improve or expand it thus offers little payoff (Clifford, 2005). The ISO 9000 standards are more popular for European companies, whereas US companies tend to favor Total Quality Management, a system similar to Lean (Seddon, 2000).

Lean

The Lean manufacturing process takes a whole system approach. The concept is based on the Toyota Production System, which has two main pillars; continuous improvement and respect for people (Cooper, Keif & Macro Jr., 2007). It is a system that is easily adaptable to any size company in any field because it is a culture and way of thinking about business more than a systematic method or tool. Its main emphasis is on eliminating waste within the system to increase productivity. Waste is very broadly defined and encompasses any materials or actions that do not add value to the product, where value is defined by the customer. Employees are empowered to creatively solve problems in a cooperative effort to constantly improve the system over time (Womack & Jones, 2003).

Lean's whole system approach, flexibility and emphasis on people make it a great candidate for implementation in a small printing company. A catchphrase often heard when talking about Lean is "do more with less"—something small printers are always trying to do to stay competitive. It doesn't require large investments in training, consultants, or certification and can be implemented over time. It's culture based approach aims to make a company that "is" Lean rather than "does" Lean and therefore continues to use the system once the novelty of introducing a new idea begins to fade (Sayer & Williams, 2012, Cooper, Keif & Macro Jr., 2007).

Lean Overview

Lean businesses strive to do more with less; to use less human effort, less time, less materials, and less space to create their goods while also creating higher quality products and services to better serve customer demand (Sayer & Williams, 2012). Unlike other approaches

to improving manufacturing efficiencies, Lean is less about being a toolset and more about a way of being and thinking about all aspects of the business. It is a long-term solution that focuses on “how” the system flows to identify and reduce waste, empower employees to make improvements every day through problem solving, build relationships, and provide value to the customer. Being a business mind-set more than a procedure to success, there is a general framework and toolset for Lean, but each individual company will tailor the principles to meet its specific needs.

Lean is a culture and a mind-set for all involved in the production cycle and therefore places a large emphasis on respect for people. Traditional management styles tend to focus more on controlling employees, creating a “perform and conform” environment. The focus is on objects and things, following procedures and enforcing standards (Cooper, Keif & Macro Jr., 2007). The opposite management style focuses on empowering employees to make decisions, think creatively and communicate ideas across the company. Where traditional management has a hierarchy of managers, the empowered management style favors a flatter organization to allow more open communication (Cooper, Keif & Macro Jr., 2007). Encouraging employees to take ownership of their roles leads to greater job satisfaction, better performance, and employee driven change (Womack & Jones, 2003).

Since management style has such a demonstrable impact on employees across a company, it is also important that the management be strongly committed to the Lean initiative. Often, companies will start moving in a Lean direction, passing instructions down to the employees, but waning interest and commitment on the part of the management diminishes overall company commitment. Managers must lead by example and act to maintain the culture through well “articulated, shared and understood values that will help guide people and their judgment” (Cooper, Keif & Macro Jr., 2007). Teams comprised of carefully selected employees dedicated to everyday improvement are also essential to employee empowerment and creative problem solving.

Lean is based on five basic principles that are the basis for all decisions made in a production system. They are customer value, the value-stream, flow, pull, and perfection.

The first principle, *customer value*, is the starting point of all Lean operations. Only the customer can determine the value of a product or service based on given needs at a specific time and at a specified price (Womack & Jones, 2003). Therefore, only the customer can define what parts of the production process add value to the finished product. To be value-added, any activity must be transforming the raw material in a way that contributes to the end value. Any activity that does not is considered waste, or *muda* (Womack & Jones, 2003, Sayer & Williams, 2012, Cooper, Keif & Macro Jr., 2007).

The second principle is the *value stream*. The value stream is defined as all the activities and events that take place to produce the product or service and deliver it to the customer. Value stream mapping is a very important Lean tool used to visually document these steps and how information and materials flow between them (Womack & Jones, 2003). The first step in value stream mapping is to carefully observe and document the current state of the production process, including employee movement, activities (value-added or not), length of time spent per task, etc. to create a very accurate depiction of the way production is being handled. Once these processes have been scrutinized and all waste has been identified, an ideal value-stream map is created with the presumption that it is a “perfect world” and only value added activities will take place. Although the ideal state is likely not achievable, it will highlight the areas where improvement is most critical. Once the start and end states have been created, in-between maps can be drawn to set goals for improvement over set time frames. Value stream mapping provides the necessary information for teams of employees to begin the continuous improvement that is called Kaizen (Cooper, Keif & Macro Jr., 2007).

Flow is the third principle and is quite simple; keep the product moving through the value stream at just the right speed from the moment the customer creates demand, preventing stoppages, and delivering the finished product to the customer at just the right time.

The product, or product components should never stop until they reach the customer. Any interruptions, waiting as inventory, or rework due to defects is considered waste and should be eliminated (Womack & Jones, 2003).

The fourth principle is *pull*. The concept of pull is that the speed and availability of downstream portions of the process will dictate the pace at which products enter the stream, thereby pulling products through the system (Womack & Jones, 2003). An example of a push system is a conveyor belt, which forces products to move from one stage to the next even if the next stage is not prepared to receive it. In a pull system, the conveyor belt would move only as the downstream processes were completed. This is accomplished through scheduling practices that keep the system moving at the correct pace, and in Lean lingo is called *takt time*. When a pull system is achieved, it prevents work-in-progress inventory (WIP) caused by bottlenecking and maintains flow. The main concept is that the customer takes one from the end of the process at the same rate as a customer places a new order. (Womack & Jones, 2003, Sayer & Williams, 2012).

The final principle is perfection. Perfection is the concept that the cycle of the first four principles should be constantly improved to reduce waste and move the current state of the value stream closer to the ideal state (Womack & Jones, 2003).

The primary goal of the five key principles of Lean thinking is to eliminate waste. In Lean, there are three types of waste, muda (waste), mura (unevenness) and muri (overdoing).

The primary type of waste or muda, has seven forms:

1. **Transport** – Any movement of the materials or products that is not required to add value.
2. **Inventory** – Keeping inventory at any point in the value stream ties up resources to finance, store, track, and move it and is never adding value.
3. **Waiting** – Waiting for any reason is considered waste including workers waiting for a machine or materials waiting to be processed.

4. **Motion** – Movement of personnel that does not directly add value to the product, such as adjustments or movement to gather supplies.
5. **Overproduction** – Producing more than the customer requires at a given time. This causes waste in several other areas simultaneously.
6. **Over processing** – Any additional time or materials that are expended to compensate for poor tool or product design, or in process work that is not seen by the end customer.
7. **Rework** – Having to fix or remake defective or improperly produced products. Rework also includes the related costs of poor quality.

It is normal for some of this waste to be inevitable, and for this reason, muda is broken into two classifications:

Type 1 muda: activities that are non-value-added but are unavoidable or necessary.

Type 2 muda: activities that do not add value and are also unnecessary or are able to be eliminated.

The goal in Lean is to reduce type 1 muda as much as possible, and to eliminate all type 2 muda.

The two other types of waste recognized by Lean are *mura* and *muri*. Mura is unevenness or variation in a process, which produces waste through defects, increased costs, late deliveries, returns, etc. Mura may be difficult to control in the setting of a quick print shop, due to the huge variability in specifications from job to job, shortened deadlines due to the customer's own poor planning, and urgent and non urgent jobs vying for positions in the queues (Rothenberg & Cost, 2004). Muda and mura are both excellent areas for statistical analysis for measuring progress and finding solutions.

Muri is the Japanese word for unreasonable and is the unnecessary overburdening of the system. This can mean pushing people or equipment beyond their capacity or asking

them to perform overly difficult tasks (due to poor design, planning etc.) (Womack & Jones, 2003). Muri is a main contributor to employee dissatisfaction, stress and poor performance (Sayer & Williams, 2012). The Lean philosophy of doing more with less does not mean giving employees more to do in less time.

Lean And The Printing Industry

Printing is unique among the manufacturing industries. The word “manufacturing” did not always describe printing. Manufacturing facilities used the Ford model and mass-produced uniform products without requiring any thought from employees. Management structures reflected this and did not focus on employee input or communication. Conversely, printing required skilled craftsmen to mass-produce custom products using special processes each time. Management did not presume to question the methods of the craftsmen, who guarded their trade secrets (Cost & Daly, 2003). Then the digital age changed everything, and many printing companies are still trying to figure out how to merge the two models of requiring skilled laborers to mass produce custom products using standard practices and procedures. The introduction of digital methods “guarantee[s]...localized speed, uniformity and repeatability,” however the workflows that create and process the digital content are reliant on and limited by the individuals involved (Cost & Daly, 2003).

Printing technology vendors have and still are consistently developing, improving, and changing the equipment and software available to printers for the traditional processes, as well as creating new methods (and software to match) for managing the business aspects. This constantly changing sea of choices has lead to many print shop owners purchasing new products for their businesses piecemeal without identifying their true needs. This leads to a “rigged system” of parts that were not necessarily meant to work well together, creating bottlenecks and decreasing throughput (Millet & Rosenberg, 1992). The ever-evolving hardware and software has also lead to changing tools for employees and requirements for their

work. As humans, we adapt to arbitrary requirements and develop methods and habits that allow us to get by with the tools available, even if those habits are detrimental to productivity. Habits are hard to break and create resistance to change within a company (Cost & Daly, 2003). These attributes created by the digital age have convoluted the business of print and lead to “as many workflow and business models as there are printing companies” (Uribe, 2003).

The transition to the digital age as well as a rocky economy have lead to changes in the competitive environment. With repeatability and uniformity the standard for any press or printer on the market, physical print quality has become assumed by customers and is now more a function of design than production (Cost & Daly, 2003). Customer service and value-added services such as QR codes, web-to-print, and VDP, have become the newest way for print shops to differentiate themselves in the market (Paparozzi & Vincenzino, 2010, Leighton, 2010). Customers are also becoming increasingly price sensitive, requiring printers to allow smaller profit margins to obtain jobs and compete with other companies.

According to the NAPL 2010 Strategic Perspective annual publication, the companies that are becoming the industry leaders in sales growth are the ones that saw the changes and challenges faced by the industry and made major organizational changes. These companies took an honest look at their methods, processes, and employees and made the difficult decision

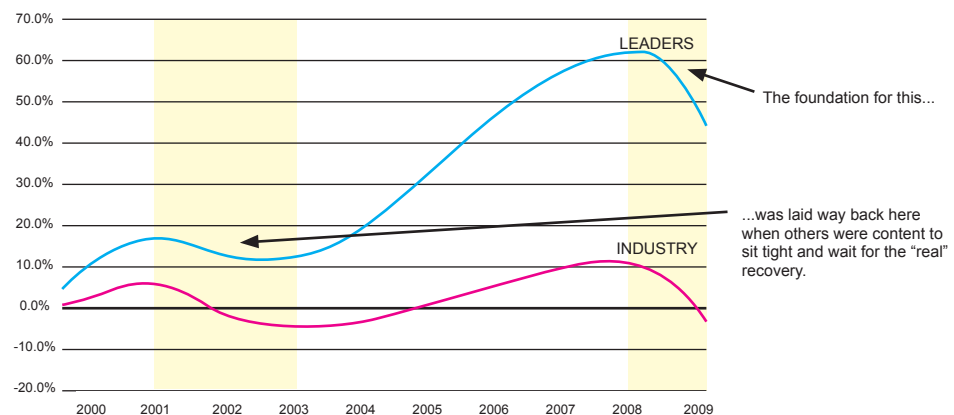


Figure 1. Cumulative sales growth for NAPL Leaders and the industry overall from Jan 1998 - June 2009. Sales include all services (not just printing) and are NAPL estimates. Shaded areas indicate recession. (Paparozzi, Vincenzino, & Wang, 2010)

to admit their weaknesses, change their operating procedures, and eliminate waste in the form of inventory, time, and unwilling employees. While the majority of printers just tried to get by and “wait-out” the economic storm by doing what they have always done, these industry leaders restructured their businesses and are now seeing huge growths despite the economy (See Figure 1.). The NAPL defines leaders as those companies who “make change, whether cyclical or structural, an opportunity rather than a threat... by making the tough decisions that other delay or avoid altogether” (Paparozzi & Vincenzino, 2010). These companies know that just adding new services and adopting new technologies is not enough. They are focused on redefining themselves, their processes, and employee cultures by “cultivating new mind-sets, skills, and responsibilities” (Paparozzi & Vincenzino, 2010). These companies are essentially adopting Lean practices, whether by that name or not.

A 2004 study conducted by Frank Cost and Sandra Rothenberg surveyed 103 small- and medium-sized printers across the country for information about their digital integration of processes and Lean manufacturing practices. Their findings showed that small firms were less motivated to expend effort in the adoption of Lean practices. There are a number of reasons for the slow adoption of Lean by smaller printing firms. Researchers have found that a lack of commitment by management, limited financial resources and a perception that Lean complicated have all hindered Lean implementation. The high diversity of products offered by small shops complicates the value stream analysis and makes implementation more daunting to management. For those who are not knowledgeable on the subject, Lean manufacturing practices are generally associated with assembly line production rather than custom product creation.

One of the biggest impediments to change in the printing industry is fear. Fear of becoming something different and losing the company’s current identity, fear surrounding the scope of implementation, fear of finding new suppliers, employees and customers and possibly losing old ones, and a fear of having to break old habits (Cooper, Keif & Prince, 2007). These

are all issues of change management, which is not an area most smaller firms know much or anything about.

The Cost and Rothenberg study also showed that small firms measured their process waste less often than larger firms and that larger firms tended to perform more statistical analysis of their production performance. Having accurate statistical knowledge of the state of the company in terms of its waste may be a strong motivator for smaller companies to adopt Lean methods for waste reduction in order to enjoy the cost savings.

Small- and medium-sized firms can enjoy many of the same benefits of Lean as large companies, such as improved quality, reduced waste, less inventory, shorter lead times, and improved cash flow. Some researchers suggest that smaller companies may enjoy more immediate benefits than large companies because they are more likely to have more multi-function equipment and more cross-trained employees (Winston & Heiko, 1990). Others may argue small companies are at a disadvantage due to lack of financial resources and understanding of Lean strategies.

What Is Workflow?

Simply stated, workflow is the series of tasks “necessary to get a job in the door, produce it, and ship it” (Gehman, 2003). A well-defined workflow is essential in a production setting because it acts as a guiding set of steps for employees to follow to produce a product as effectively as possible. Well laid out workflows act like road maps for information and material flow through the production process and provide directions for handling common issues consistently to ensure quality. This mapping also allows for automation of predictable steps to varying degrees. There is a myriad of workflow management software, and more in development, that promises to coordinate and automate the process of moving files, job information, and materials through production. However, these systems are costly and investment in these systems by small printers has remained quite low (Leighton, 2010).

The complexity and number of different workflows a company has depends on the diversity and complexity of the products it offers. Many small print shops offer a wide range of products and services to remain competitive in the industry, and thus will have a wider range of workflows for different jobs. Workflows may fail for many reasons, but most commonly, the workflow is too narrowly defined for a specific job type and is not flexible enough to handle unexpected situations. On the other hand, some companies try to create all encompassing workflows that are too difficult for the employees to understand and ultimately become useless (Uribe, 2008, Poyssick & Hannaford, 1996).

It is important to acknowledge the differences between the concept of workflow and the Lean principles. Workflows are not value streams. Workflows show a sequence of steps in a production process, but they do not focus on how the information and materials flow from one step to the next (Cooper, Keif & Macro Jr., 2007). They do not show what happens in between each step and what materials, resources, or time is spent getting the product from one operation to the next. In a push system, it is common for jobs to be stored as work in progress while they wait for availability on the next piece of equipment. They also do not show how communication is happening, although workflow management software aims to act as a communication tool between these steps. In the value stream, the “how” questions are answered and documented to create a clear picture of what is actually happening on the production floor in order to identify waste (Cooper, Keif & Macro Jr., 2007).

Typical Production Workflow In A Print Shop

In the printing industry there are three main processes that all printers need to produce their products: pre-media, press, and finishing. Many smaller printers have in-house designers that offer graphic design services to their clients which are grouped in with the pre-media stage of production. In Kipphan's Handbook of Print Media, he graphically outlines these stages of print production to clearly show the flow of materials and information through the over-

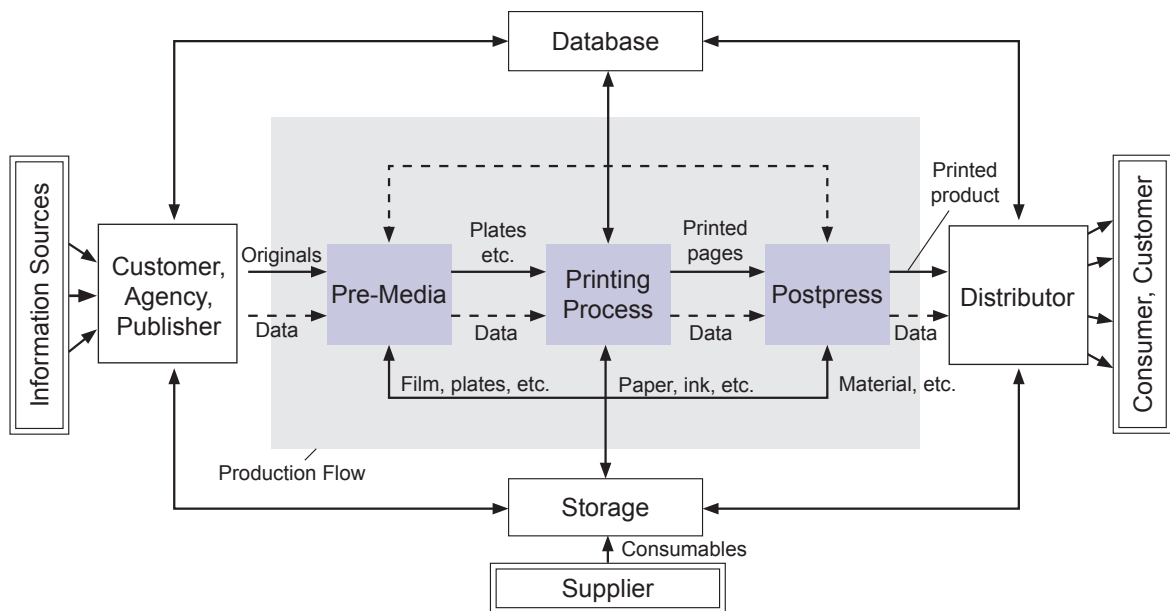


Figure 2. The production, material, and information flow in print production (Kipphan, 2001).

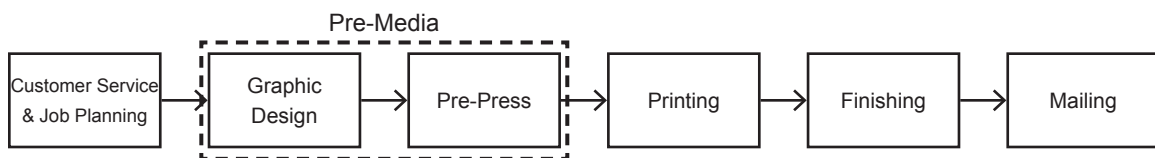


Figure 3. Six main workflow steps by department

arching system that is print (See Figure 2). Within each area, printers will define their own workflows based on client needs and plant set up.

Typically, a print shop's workflow is comprised of six main workflow steps that correspond to the departments that handle them (See Figure 3). These departments are: customer service and job planning, graphic design and content creation, pre-media, printing, finishing, and mailing. A separate final step for distribution can be added for those companies who ship their products or deliver them to clients separate from performing in-house mailing as a value-added service for clients.

Jobs begin in the customer service department when a customer walks-in, calls, or electronically submits a job. The customer service department is responsible for estimating costs, time, and materials and quoting a price to the customer. In order to create accurate estimates, customer service employees must have a thorough understanding of the production system, material availability and scheduling procedures for the company (Millet & Rosenberg, 1992). Production planning for each individual job is critical at this stage to prevent communication problems and rework further down the line. Research by Millet & Rosenberg in their *Primer for Graphic Arts Profitability*, showed that poor or absent front-end job planning is one of the single biggest problems with graphic arts companies.

If the job requires any digital typesetting, page layout, or graphic design work, the customer service department then hands the job to the graphic design department. The designers are responsible for creating the digital content for the client, then supplying that client with a proof. With the prevalence of digital software and the ability to send PDFs over the Internet, many small print shops have moved to sending soft-proofs via email to clients for approval prior to printing. This eliminates the additional work, cost, and time required to generate hard-copy proofs for a client.

Once client approval is received, the job enters the pre-media phase. Pre-media encompasses “all the steps which are carried out before the actual printing” (Kipphan, 2001). With digital workflows this means impositioning, color management, and plate-making. The advent of computer to plate technology has made the production of printing plates much simpler and faster, allowing designers to send the information straight from graphic design programs (Leighton, 2010).

At this point the workflow splits into three different branches, electrostatic color printing (digital color), electrostatic black and white printing (digital black and white), and press. Which branch the job travels along will depend on the specifications from the client for run length (number of pages), color, quality, and price. These three branches make up

the press or printing stage of the workflow. If the job will be printed on a color copier or a black and white copier, the designer completes the pre-media stage (impositioning and color management) and sends the data file to the appropriate department to be printed on the proper substrate. If the job will go to press, plates will be made in the pre-media phase and travel with the data file to be printed by the press department.

Once printed, the job travels to the finishing department where operations such as cutting, collating, binding, laminating, and folding take place. This is the step where front end planning makes a huge difference in the successful assembly of a printed job. If proper planning was not done at the first phase of the workflow for job properties such as impositioning, the problem travels downstream. These mistakes may not be caught until assembly begins and pages are out of sequence for binding or laid out wrong for uniform cutting.

Once the job has been printed and all finishing completed, the job is either directed to a shipping and mailing department or returns to customer service to be given to the client. Many print shops offer in house mailing as a value-added service. Clients can order monthly newsletters printed and direct mailed to recipients without the hassle of mailing themselves.

If at any point in the workflow a mistake is made, found, or the client is dissatisfied with the output, the job must return to the workflow to be reprinted or corrected. These reworks are costly to printers and can often be prevented with good up front planning (Millet & Rosenberg, 1992).

Existing metrics for analyzing productivity and the value stream

Value stream mapping is the starting point for Lean implementation within an organization and is a powerful tool for analyzing the current manufacturing processes. A value stream map creates a visual representation of how materials and information flow through a system and displays value-added and non-value-added activities, performance metric for each activity, inventory at different stages, and throughput time (Rizzo, 2011). Once a detailed map

is created for where the company currently stands, then future state maps are created to show where Lean tools and efforts should be targeted for maximum benefit. The following sections describe types of data to be collected when creating a value stream map.

Process Data

Process data provides the average performance information about a piece of equipment and is useful in determining where bottlenecks occur.

- **Cycle time (CT):** The time the equipment or process takes to complete one repetition of the particular task. Cycle time is typically measured from “start to start” which means from the beginning of one product’s processing to the start of the next’s (Rizzo, 2011). Cycle time can be categorized into three subcategories:
 - *Manual Cycle Time:* The hands on time spent by the operator loading, unloading, adding components, etc. while still at the same machine or process.
 - *Machine Cycle Time:* The amount of time the machine spends transforming the part.
 - *Auto Cycle Time:* The time the machine runs without the aid of an operator (Throughput Solutions, 2011).
- **Changeover (CO):** Refers to the time spent switching a machine or workstation for a new operation. Specifically, it is the time between when the last good piece from the previous job was completed until the first good piece from the following job is completed and verified as acceptable (Rizzo, 2011).
- **Uptime (UT):** The ratio of the actual production time to the available time for a given piece of equipment (ToolingU, 2012). Total available time refers to the total shift hours less employee breaks, planned maintenance and planned downtime.

- **Spoilage rate/Waste (SR):** The percentage or amount of defective product.
- **Number of people:** How many employees operate the piece of equipment or workstation.
- **Batch size:** The number of units for a given job. Long press runs equal larger batch sizes (number of pages).
- **Production Lead Time:** Is the time between when the customer places an order and when it is shipped as a finished good.

Inventory Data

Inventory data is collected at each stage of the production process to identify how long raw materials, work-in-progress (WIP), and finished goods must wait before moving to the next phase.

Vendor & Supplier Data

Vendor and supplier data is a key component of the value stream map, as it is the start of the production process. It identifies the company's suppliers, amounts of materials delivered, how long it takes from order to delivery, and how often deliveries are made.

Process Cycle Efficiency

Process Cycle Efficiency (PCE), also known as the *value-added ratio*, is a key metric used when value stream mapping. It is calculated by dividing value-added time within the production process by the *production lead time* (or total time from order to shipment). It shows what percentage of the time used to manufacture a product was spent on value-added activities. It is common for more than 97% of lead-time to be non-value-added, or waste (Rizzo, 2011).

Overall Equipment Effectiveness

Overall Equipment Effectiveness (OEE) is a key metric used in Total Productive Maintenance programs. It combines machine availability, performance rate, and quality rate to measure how well a machine is being utilized in relationship to its potential (Rizzo, 2011, Throughput Solutions, 2011). OEE measures “losses” that are effecting a piece of equipment. The six major losses that are common in equipment are equipment failures, setup and adjustment time, idling and minor stoppages, reduced speed, defects, start-up and reduced yield (Hannover, 2011). The inclusion of setup and adjustment time as a loss is an arguable subject. Some claim that since this time is generally included in the quote given to the client, it is not a loss. Other Lean proponents argue that since setup and adjustment do not directly transform the raw material in some way, they are waste in the form of type 1 muda—waste that is unavoidable or necessary. Depending on the job run lengths and changeovers, an OEE of 50% would be considered good in the printing industry. Equipment with an OEE below 30% will need to be targeted as part of a Lean initiative (Rizzo, 2011).

The equation for calculating OEE is:

$$\text{Availability} \times \text{Performance Rate} \times \text{Quality Rate} = \text{OEE}$$

- **Performance Rate:** Compares the actual output of a machine to its possible output. This essentially equates to how fast a machine can run compared to how fast it is actually running. Performance rate is affected by poorly operating machinery, machines that have been purposely slowed down (example: press operating slower than capacity), inefficient work processes, and material variations (Hannover, 2011). If a digital printer should be able to produce 100 copies a minute, but is only producing 85, then it has an 85% performance rate.

- **Machine Availability Rate:** Actual time available for production after subtracting all planned downtime. Breaks, meetings, material shortages, or other constraints within your production process cause planned downtime. Unplanned downtime is caused by breakdowns, set-up time, idle time, and minor stoppages (Hannover, 2011). For example, if a machine could potentially run for an 8-hour shift, less planned downtime of 1 hour, means it has an actual available time of 7 hours. If the machine is actually used for only 6 hours within the 8 hour shift (due to unplanned downtime), then the availability rate is $6/7$ or 86%.
- **Quality Rate:** How many good/acceptable outputs are produced compared to defective parts during the time period the machine was running. For example, if a digital printer produced 100 pages and 10 are defective, the quality rate is 90%. Quality rate is affected by: improperly maintained equipment, inconsistent materials, operator error, misalignment within the machine, and too much guesswork to achieve results (Hannover, 2011). Defects are problematic because they reduce profits, increase waste, and sometimes will not be caught before being handed off to the final customer, leading to lower customer satisfaction.

Takt Time

Once future planning has begun, one of the first steps is to calculate takt time. Takt is a German word meaning pace or rhythm. Takt time is the rate or pace that products must be created to meet customer demand and can be calculated by dividing time by demand. Ideally, an entire Lean system will perform based on takt time, with the customer dictating the speed of the system. For example, if a company's customers need 100 jobs per day and staff has 480 minutes per day to produce them, then the takt time is 4.8 minutes per job.

Implementing Lean: Foundations

Some Lean concepts and tools may be able to be implemented quickly, but it's important to remember Lean is not a quick fix for any business. It requires a fundamental change in the way the company views its processes and how its people communicate and interact with one another. Before any Lean tools can be implemented, the company must build the foundations required to begin and sustain the major organizational change.

Company Culture and Team Building

The power of Lean lies less in its toolset and more in its nontraditional way of being and thinking about all aspects of the business. Before any of the Lean tools or initiatives can be implemented, management must be well informed and extremely dedicated to creating long-term cultural change within the organization. Often, companies will initiate new programs for improving the business in some way, but interest eventually wanes due to management's diminishing commitment (Oakland & Tanner, 2007). Therefore, how successful a company is at becoming Lean will be determined by how fully management embraces and relentlessly pursues this shift in company values.

Lean culture places great emphasis on respect for people. Traditional management styles tend to focus on controlling employee behavior to meet certain standards. In contrast, the Lean management style focuses on empowering employees to make decisions, think creatively and communicate ideas across the company (Sayer & Williams, 2012, Cooper, Keif & Macro Jr., 2007). Encouraging employees to take ownership of their roles leads to greater job satisfaction, better performance, and employee driven change (Womack & Jones, 2003).

It is imperative for managers to lead by example and act to maintain the culture through well articulated and understood values. All Lean objectives and metrics must be communicated in a concise, understandable format to all employees. Managers must also learn to relinquish their traditional total authority roles by learning to facilitate open discussions and

demonstrate trust in employees' power to make decisions. Both managers and employees must take part in ongoing learning during meetings and on the job, cross-department training. These changes should help flatten the company structure and encourage collaboration between upper management and all levels of the staff.

Teams are extremely important in a Lean culture (Coleman, 2008). Carefully selected employees should be brought together to begin designing methods for continuously improving the culture and value stream. Allowing teams to set up new standard practices and establish new production systems will help other employees see the changes as improvements rather than new demands from management. Teams will likely need training in effective communication and conflict resolution as they move through the stages of norming, forming, storming, and performing. Management's support of team goals will be critical for helping the team succeed in achieving results (Coleman, 2008).

Quality at the Source

Foundational to Lean is the concept of building quality at the source. In traditional manufacturing, companies typically have an entire quality control department dedicated to routinely inspecting samples to make sure they fall within the acceptable tolerances. If problems are found, batches are designated for rework and waste is created. Each department operates independently and each is trying to meet individual production schedules. When equipment begins behaving badly, workarounds are found to keep to the schedule rather than identifying the root cause. Operators are expected to keep the process moving because time is money and some defects are acceptable. This production-focused culture is not focused on quality above all else, resulting in a workplace where no one is really responsible for output quality.

In a Lean facility, each person is responsible for quality at his or her stage of production. Employees are encouraged to improve the system and identify problems. If the output is not meeting the customer's standards, production is stopped while the root cause

is determined and fixed. If the company were to continue running production and just ate the cost of defects, there would be very little consequence for not fixing underlying problems. Masked problems then continue to worsen until production is forced to stop for huge repairs that could have been prevented with earlier maintenance.

Quality at the source is yet another fundamental differences between Lean and traditional manufacturing. Problems are brought to the forefront rather than masked for the sake of production. People involved are encouraged to take responsibility for quality at each step and creatively solve problems to achieve the best possible results. It is a way of thinking that must be integrated daily into the new company culture by management that is committed to Lean implementation (Jidoka, 2006, Cooper, Keif & Macro Jr., 2007).

5S: Sort, Straighten, Shine, Systematize, Sustain

The 5S system was first used by Toyota as a way to create a clean, well-organized, high performing workplace. The belief was that a dirty, cluttered, disorganized production floor generally slows productivity, reduces employee morale, and produces poor quality products (Cooper, Keif & Macro Jr., 2007). 5S serves as an excellent springboard for starting a Lean initiative as it gets all employees involved in improving their workplace. They are encouraged to work together and take ownership of their production area, which contributes to establishing the Lean culture. 5S also employs visual management allowing workers to quickly and clearly identify issues (Cooper, Keif & Macro Jr., 2007). It facilitates ongoing organization of workspaces and improves communication between individuals. The five steps in the 5S process are: sort, straighten, shine, systematize, and sustain.

#1 Sort. This step is about looking at every item on the shop floor and removing anything that is not required for the employees to perform value-added activities. It is a more ruthless endeavor than simply tossing out the garbage and other things that probably aren't necessary to

keep anymore. It is about evaluating every single item and leaving only the absolute essentials in the workspace.

Reorganizing the entire production floor at once is an overwhelming task, so identifying specific work areas is key. Using the current VSM, choose an area of the shop to focus on that corresponds to one group of connected processes. In the example of Small Printer, the press would be one process area to focus the 5S effort. Once 5S has been performed on individual areas, they can become “islands of excellence” that help inspire further improvement and motivate employees to continue the effort.

To begin this process all employees should be involved as they are the ones who know which items are actually useful. All items that cannot be immediately thrown into a dumpster or recycled, but are questionable in their use should be brought to a designated area on the shop floor. Every single item should be evaluated! A good way to determine if items should be moved to this holding area is to ask if it was used in the past X number of days. For example, if a set of wrenches next to the press was not used in the last 14 days, then they should go to the holding area.

Red tags are very useful at this stage to label questionable items. These tags should include information such as the work area the item came from, the date tagged, the reason for tagging, the desired disposition, the name of the person who tagged it, and an area for any needed supervisor sign-off prior to disposal. Items should remain in the holding area no longer than one week to allow the entire production team to review them. If an item was not needed during this time period it should be permanently discarded (Cooper, Keif & Macro Jr., 2007, Sayer & Williams, 2012, 5S Philosophy, 2003).

#2 Straighten. Now that the work areas are cleared of unwanted items, a new organizational system must be developed. Visual systems, such as shadow boards or color-coded labels and area markers, are very effective in production environments because they allow quick retrieval

and replacement of items from a designated spot. This method gives every item its own place so things are always where they are expected to be. The most used items should be within arms reach of where they will be used. This will be critical when working to reduce setup and lead times.

#3 Shine. All employees must be responsible for cleaning their workspaces and equipment on a daily basis. This includes wiping down all equipment, sweeping the floors, and putting every item back in its place. All areas and equipment should also be deep cleaned on a regular schedule to ensure the cleanest possible work environment. Although this step only requires a few minutes at the end of each shift, it may be the most difficult to enforce (Cooper, Keif & Macro Jr., 2007). Traditional ways of viewing the workplace as individual, distinct departments leads employees to feel like cleaning is not their job. This must be addressed and enforced by management through daily checks and evaluations of each workspace.

Despite the simplicity of this step, it offers several very important benefits. When people work in a clean space, they tend to have more pride in their space and a more positive attitude. A clean environment is always safer than a dirty one and will help avoid damage to materials (like paper) caused by leaks and spills on work surfaces. And finally, when the environment is clean problems with equipment, such as leaks are immediately evident and can be addressed before causing loss in productivity (Sayer & Williams, 2012).

#4 Systematize. Once an area has been thoroughly organized and cleaned, systems must be put in place to maintain the order. Standard operating procedures for sorting items, discarding waste, and cleaning equipment should be documented. Management should perform regular evaluations of the departments and review any checklists created to delegate maintenance activities.

#5 Sustain. The previous step of systematizing the 5S process will help set up methods for sustaining the newly achieved state. Management must be dedicated to developing a culture where everyone understands the importance of the new practices and is committed to maintaining and continuously improving the healthy state of the shop.

The changes outlined here are just an overview of changes a Lean organization will strive toward. Major shifts in the way people think and behave will not happen overnight or after an all-day workshop. This type of change will require time and patience, but having a good image of where the company wants to be will help keep efforts focused. Lean is about continuous improvement, not just on the production floor, but in every aspect of the organization.

Implementing Lean: Tools

Setup reduction

Setup occurs when steps are taken to prepare a machine or process to produce a different product. Setup time is defined as the “total elapsed time from completion of the last good part from the previous setup to the first good part from the new setup” (Albert, 2004). In Lean, this is known as SMED or single-minute exchange of die and was first conceptualized by Toyota engineer Shigeo Shingo in 1969 (Chen & Meng, 2010). Today, the term is applied to any process that has undergone analysis of equipment make-ready and systematic reduction of setup time (Cooper, Keif & Macro Jr., 2007).

To be considered value-added, an activity must transform the raw material in a way that contributes to the end value as defined by the customer (Womack & Jones, 2003). Although setup is necessary to prepare equipment for performing value-added activities, it is not directly acting on the raw materials. Customers do not value setup; they value output. Therefore reducing setup time is critical in reducing non-value added time (waste) and

production lead times. Faster setup times also allows for a greater degree of flow through the system, less WIP between steps, and the ability to economically produce smaller batch sizes (Albert, 2004).

In addition to being more flexible in meeting customer demand, the time gained during each shift from shorter changeovers becomes sellable hours and could allow the company to lower prices and attract new customers. There is no need to keep purchasing newer, faster equipment when the additional capacity can be gained by focusing on SMED!

The SMED methodology starts with identifying all the required steps, tools and materials required to changeover a piece of equipment from one product to the next. Several variations of the specific steps for SMED exist in the literature, but all have the following steps in common.

1. Distinguish internal and external setup operations.

External operations are those that can be performed while the equipment is running. For example, when running a printing press this could include preparing the paper stock for the next job. Internal operations are those that must be performed while the equipment is stopped. For Small Printer, the press must be stopped when hanging new plates (Cooper, Keif & Macro Jr., 2007, Albert, 2004, Chen & Meng, 2010).

2. Convert internal setup operations to internal ones

This step requires operators to question the traditional methods and objectively determine if an operation must be performed with the equipment stopped. Each activity must also be evaluated to determine if it is really needed at all. Changing as many steps as possible to external will allow operators to perform setup functions in preparation for the changeover so that little time is wasted while production is stopped (Chen & Meng, 2010, Cooper, Keif & Macro Jr., 2007, Albert, 2004, Sayer & Williams, 2012).

3. Standardize as many tools and procedures as possible

Wherever possible, visual organization such as color-coded tools, should be used to organize and standardize the workspace. All tools and supplies should be within arms reach while performing setup. Using jigs to reduce time spent measuring or a set of standard bolts requiring the same tool can substantially speed up changeovers. Once all activities have been thoroughly evaluated, a set of standard procedures should be documented and implemented to make each changeover consistent. Adjustments that require tweaking before the machine is ready, such as registration, should be reduced as much as possible through creative problem solving (Cooper, Keif & Macro Jr., 2007, Sayer & Williams, 2012).

4. Evaluate and repeat

Evaluate and document the performance improvements achieved by the previous three steps. Employees should be able to see their progress and be inspired to make further improvements. The process must be repeated to achieve the continuous improvement that is the hallmark of Lean.

Total Productive Maintenance

Total Productive Maintenance (TPM) is a methodology for ensuring equipment is in top operating condition when it is needed. It aims to reduce breakdowns, defects in output, long make-readies, and speed losses due to poorly maintained equipment (Rizzo, 2008).

To maximize production within a manufacturing facility, all equipment must be running as well or better than it is specified to. The best way to achieve this is by performing daily maintenance rather than waiting until something is broken. In most organizations, employees take a hands-off approach to maintaining equipment within their departments. When something breaks or needs tweaking, maintenance employees or outside service providers are brought in and made responsible for the repair. Lean turns this relationship

around and puts the users of the equipment in charge of performing routine daily maintenance (Cooper, Keif & Macro Jr., 2007, Rizzo, 2008, Sayer & Williams, 2012). Employees should be trained on how a machine works and provided with standardized descriptions for the maintenance tasks. This not only frees up the maintenance staff to work on larger issues, but also helps ensure machines continue to run properly.

TPM is divided into three maintenance categories: Autonomous, planned, and predictive maintenance.

Autonomous maintenance is the scenario just described, where employees perform routine daily tasks to keep equipment performing optimally. This empowerment of the operators can be taken further through training so minor breakdowns or repairs can be made without the downtime associated with placing a service request.

Planned maintenance takes a proactive approach to prevent machine failures. In most equipment, parts will wear out over time and need replacing or simply require more in-depth servicing. For Lean companies, planned maintenance is key to ensuring equipment performs optimally whenever it is needed (Rizzo, 2008).

The third type, predictive maintenance, aims to anticipate machine failures to better control the costs associated with them by servicing them at just the right time. The knowledge required to predict failures usually comes from past experience of needing to repair equipment after so many products are produced or a certain amount of time has elapsed (Cooper, Keif & Marco, 2007).

The metric used to track machine performance is the Overall Equipment Effectiveness (OEE) discussed previously.

Kaizen

Kaizen is Japanese word that generally translates as ongoing betterment or improvement (Sayer & Williams, 2012). As a business philosophy, Kaizen focuses on making

incremental improvement a daily activity. The goal of Kaizen is centered on eliminating waste and improving flow within the value stream. Continuous improvement is achieved by applying Lean tools and methods such as 5S, setup reduction, TPM, and visual management, and by changing the organizational culture.

Kaizen is about respecting people (Sayer & Williams, 2012). People are at the heart of every organization—tools, equipment, and facilities are all important to generating output, but excellence driven by humans. A company practicing Kaizen rewards creativity and innovation from every individual and embraces suggestions for change.

Kaizen is also about pursuing long-term benefits rather than short-term gains. In traditional western organizations, managers tend to have a myopic, results driven mentality. This inevitably leads to less than optimal working conditions and disregarding input from employees. Conversely, Kaizen is process focused. Employee initiated improvements are celebrated and each change is in pursuit of the larger, long-term goals (Geoffrey, 2006).

Kaizen Events. The concept of Kaizen becomes a tool in Lean when it is used as an event. Kaizen events are used to focus in on a particular workspace or segment of the value stream. During the event, a team of employees from across the value stream, particularly the segment of focus, is brought together for a one- to three-day period with the goal of collaboratively solving an issue. The issue can be broad, such as completing 5S on a workspace or narrow, like reducing setup times on a piece of equipment.

Kaizen events are an excellent way to engage members of the entire workflow and give everyone the opportunity to contribute. When first starting Kaizen events, getting over the initial skepticism can be a challenge. The key is to “eliminate fear and reluctance [by] educat[ing] people on the possibilities and give them the chance to carry out their ideas” (Geoffrey, 2006). Kaizen is an opportunity for operators to help themselves with the support of the company and the management. When someone has an idea, he or she develops a sense of

ownership in making it work. This often leads to improved communication between operators and management, increased morale, and the feeling of empowerment that is central to Lean (Geoffrey, 2006).

Kaizen is about a cycle of never-ending improvement, so Kaizen events are not meant to happen once and be done. They should be done repeatedly across the value stream. Once the entire stream has undergone Kaizen it starts back at the beginning. Ideally, by the time a process undergoes its next Kaizen, new problems will have risen to the surface and require new ideas for fixing them. Remember, Lean is about revealing and resolving problems, not hiding them.

Flow

Conventional manufacturing is typically set up to perform batch processing of work. Machines are setup to perform the longest possible run, spreading costs across the maximum number of units to create the lowest possible per unit cost. Lead times are long to accommodate the grouping of like orders together with fewer changeovers and WIP accumulates while waiting for downstream processes to be available. This is a classic “push” system where each process is working to its own schedule and pace. In contrast, Lean value streams are set up to pull materials through the system only when downstream process need them, creating the concept of flow.

Flow and waste elimination work together in Lean to create an unobstructed, continuous value stream. When a value stream has flow, “one process make[s] only what the next process needs when it needs it” (Rother & Shook, 2009). When all processes are linked in this way, the raw materials will not stop moving until they have been transformed and delivered to the customer. There is little or no time for non-value-added activities that interrupt flow. Work-in-progress and general inventories tie up capital, space and resources to manage without adding any value and therefore are reduced or eliminated. Safety inventories also mask

problems in the value stream by providing additional resources to cover any rework that results from poor quality management or processes. It protects the stream from experiencing any real consequences (other than the monetary capital invested in materials) that would inspire action and inevitably perpetuates the problem (Womack & Jones, 2003).

Cellular manufacturing

In a manufacturing cell, multiple processes are set up and linked together so that when a part enters the process, it is not set down until it is finished. This is the opposite of batch processing where the first step is completed on all parts before the second step can begin. When restructuring the value stream, the use of manufacturing cells will allow continuous movement and eliminate WIP.

Kanbans

For flow to exist within a value stream, processes need to know when material is needed downstream. This is achieved using a kanban system. A kanban can be any visual indicator, such as a light, card, buzzer, or simply an empty space, as long as it signals how much of what part to produce (Sayer & Williams, 2012). A classic kanban example is a two-bin system where each bin holds 20 parts. When the downstream process empties bin one it begins drawing from bin two. The upstream process sees that the first bin is empty and begins producing units to fill it again. In this way, the downstream processes pull materials through the preceding processes.

Supermarkets

Within value streams there are often places where truly continuous flow is not possible and small batching is necessary. This can be caused by large differences in process cycle times, when delivering one part at a time is unrealistic like in the case of suppliers, or when a process has long or unreliable lead times. In the two-bin example, the bins would be stored in what is

called a *supermarket*. When the downstream process withdraws material from the supermarket, a withdrawal kanban is sent and triggers a production kanban for the supplying process. Supermarkets are not meant to hold WIP that is pushed down the value stream! Only when the downstream process signals need should upstream process produce—and it should only produce the quantity that is needed.

Identifying the Pacemaker Process

When used effectively, kanban systems allow scheduling to take place only at the one process step that creates the initial pull for the system. This process step is called the *pacemaker* process and sets the rate of flow for the entire value stream, ideally to the takt time. Upstream processes only produce enough to replenish what the pacemaker has consumed. Pacemakers are often set at bottleneck points that can identified using the current state value stream map or VSM (Sayer & Williams, 2012).

All processes after the pacemaker must produce in a continuous flow. Since the pacemaker sets the flow rate for the entire system, no supermarkets (except those for finished goods) should exist downstream. Once parts are released from the pacemaker they are processed to completion. Because of this, the pacemaker is often the most downstream process in the value stream (Rother & Shook, 2009).

FIFO Lanes

FIFO stands for “first in, first out” and is used to link two separate processes in place of a supermarket. FIFO lanes are typically used after the pacemaker, where continuous flow is required. Each FIFO lane has a set maximum capacity, which when reached, forces the upstream processes to stop production until the downstream process can catch up.

Load Leveling

Load leveling, also called Heijunka, is the practice of leveling the product mix to “distribute the production of different products evenly over a time period” (Rother & Shook, 2009). This is in contrast to traditional practices of producing long runs of the same or similar products to achieve economies of scale. Flexible production of an even mix of output allows manufacturers to serve clients immediate needs by reducing WIP and lead times.

Similarly, volume leveling involves releasing small, consistent amounts of work into the value stream. Gradually releasing work helps maintain takt time and pull, prevents unnecessary stress on people and equipment, and reduces the need to expedite jobs at different process stages. The term “pitch” is used to describe the amount of time “required to make a standard container of a finished product” (Sayer & Williams, 2012). Pitch is calculated by multiplying the number of finished items in a container by the takt time. The pitch can be used as the basic scheduling unit when load and volume leveling (Rother & Shook, 2009).

Chapter 3

Research Question

What is the current value stream of Small Printer and where are the sources of waste within the system? What would an ideal and incremental future value stream map look like and how could the firm work toward those goals?

Chapter 4

Methodology

The following methodology seeks to answer the research questions by achieving three primary goals:

1. Create an in-depth example of how to create value stream maps.
2. Use common Lean metrics to identify waste.
3. Generate future goals and recommendations for Lean implementation.

The creation of value stream maps are specific to a small print shop and address common issues encountered when mapping systems that produce mass-customized products. The Lean metrics and tools applied are tailored to Small Printer's situation to identify many forms of waste and inefficiency common within the industry. Careful observation and documentation of the company's operations yielded valuable data to be used in analyzing the current state of the production processes and was necessary for generating future goals and recommendations for Lean implementation. Individual processes were documented to learn how materials and information flow through the system, as well as in-depth observation of daily activities performed within individual departments. These two viewpoints allowed for a comprehensive look into the current state of the system and aided in the identification of opportunities for improvement. Upon completion, the researcher intends to make the case study available to the National Association for Printing Leadership (NAPL) and the Printing Industries of America (PIA).

Sample

All data was collected from a small, 6-employee, quick-print shop. For the purpose of this study, the company is referred to as Small Printer. Despite its size, the company offers a full range of print services, including, but not limited to digital color and black and white printing, 4-color and 2-color offset lithography presses, cutting, scoring, folding, many forms of binding, full service mailing, and in-house design services. Data was collected over a short period during the spring quarter of the 2012-2013 school year.

Procedure

Identifying Product Families

Before beginning observation, the researcher met with several employees to determine which product families would be the focus of the value stream mapping. In choosing each product family, the aim was to illustrate different workflows that highlight how information and materials flow through the shop's various systems. For example, one product family chosen was digital color printing, which includes business cards. Business card orders begin at the customer service planning end, travel through the graphic design department, then are output to a digital printer. The printed cards travel to the finishing department to be cut before being packaged for shipment or customer pickup. A second product family included monthly mailers, such as a newsletter or company brochure. This product family had many more steps in finishing than the business cards which helped document the procedures used within the mailing department.

Significant overlap was expected between the product families' value streams, particularly at the customer service and design stages. This overlap helped in identifying bottlenecks that slow production across all processes.

Initial Observation

Once the researcher determined which product families to focus the value stream mapping on, data collection began. Data was collected through direct observation with the aid of a video camera when needed. The researcher's style of observation relied heavily on visual information gathering before the use of verbal questioning. Her goal was to prevent bias in the study and help ensure employees behave as closely to their normal patterns as possible.

To begin the process of gathering data and analyzing value streams, the researcher spent 4 hours simply observing the entire shop, starting with customer service and moving through the typical workflow stages. Since the company is quite small, with only 6 employees, each employee roughly corresponds to each of the departments within the shop. The aim was to gain a better understanding of the current daily operations and observe how the processes are being performed.

Job Documentation

Next, the researcher followed specific jobs, determined by chosen product families, from initial customer service, through job estimating, planning, pre-media, printing, postpress, shipping and invoicing. A total of five jobs were fully documented and included in this study—one to two within each product family.

Product Family: Digital Color Printing			Job Type: Business Cards	
Quantity: 250 cards		Print Specifications: Color, duplex	Finishing Specifications: 2 folds, 2 tab closures, address printing	
Activity	Employee	Method	Time Spent	Issues / Comments
Customer emails designer with job specifications	2	email is printed	30s	
Designer walks printed email to front desk to be written up as job ticket	2	walking email to desk	5s	No electronic scheduling system in use. Sole reliance on written instructions.
Service employee inputs data into invoice system and prints job ticket.	1	invoice software	24h	backlog of jobs at front desk waiting to be written up
Job ticket is printed and given back to designer	1	walked to designer	10s	

Table 1. Individual job data collection - open format worksheet.

The steps and activities performed throughout the process were thoroughly documented using a series of worksheets shown in Table 1. For each activity recorded, supplementary information such as the number assigned to the employee performing the action, the method by which the operation is performed, the time spent, and any issues or comments. Activities also included wait times, transportation of materials, and inventories or WIPs. The open format sheet allowed the researcher to document events as they happen, rather than following predefined workflow based on the researcher's expectations.

In addition to documenting activities as they occur, other process data was gathered where applicable, including cycle times, changeovers, uptimes, defects, number of people, and batch sizes where applicable. These values were entered into the following chart (Table 2) and were later used in creating the process boxes for each activity within the value stream map.

Product Family: Digital Color Printing				Job Type: Business Cards	
Quantity: 250 cards		Print Specifications: Color, duplex		Finishing Specifications: 2 folds, 2 tab closures, address printing	
Process Data	Premedia	Press	Postpress	WIP	Shipping / Delivery
Changeover Time					
Cycle Time					
Manual CT					
Machine CT					
Auto CT					
Defects					
Number of People					
Batch Size					
VA Time					
NVA Time					

Table 2. Process data collection worksheet

Creating the Current Value Stream Maps

Once the job documentation stage was completed, the researcher began drawing the current value stream maps. The job documentation phase had familiarized the researcher with the shop's processes and provided measures of time for specific activities that were used during the mapping phase. For each product family being mapped, the following steps were used in conjunction with standard methods for hand drawing value stream maps (see Appendix A). The researcher observed production using a clipboard with a large sheet of paper, pencil, eraser, stopwatch, and video camera. Process steps that happened quickly or were complicated were filmed to allow accurate recording of cycle time and other process data.

1. Observe the production line from back to front, starting with the end customer and working back to the suppliers.
2. Begin the value stream map by focusing on material flow. This is shown on the bottom portion of the value stream map using process and data boxes. Diagram the various component steps.
3. Gather data over time for each step including defect rate and changeover time. This data is placed in the data boxes below the process steps.
4. Add the inventory and wait times between process steps.
5. Note where materials are currently being pushed or pulled through the system using the appropriate arrow designations.
6. Observe and diagram the information flow throughout the system.
7. Create the timeline for the value stream, separating the value-added time from the non-value-added time using the data collected in each box.

To provide a visual basis of what a “current” value stream map looks like, an example is shown in Figure 4 for a digital print job.

Value stream mapping takes time and is a repetitive process. Each map was redrawn multiple times to gain an accurate view of the production process.

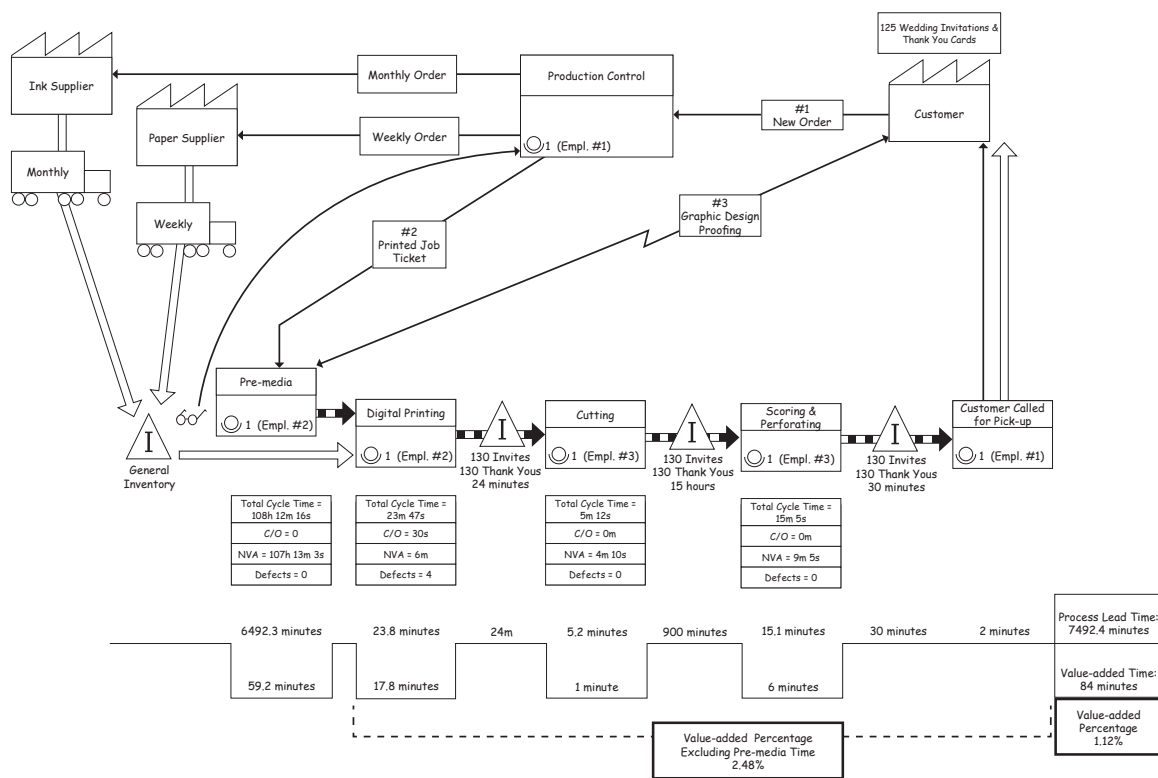


Figure 4. Example value stream map for a digital print job.

Analysis

Once the current value stream maps were completed, waste was identified within the system. To aid in highlighting the waste at each step, an in-depth process analysis can be performed, if needed. This analysis documents each step in the sequence, the time required, if value was added, and the type of waste involved, if any. An example of such an analysis is shown in Table 3 for the value stream map shown in Figure 4.

Once waste had been identified, the ideal state maps were generated. The ideal states have little to no waste in the value stream. Although this may be unachievable, it is used to highlight where waste currently exists within the system and expose problems. The ideal maps embody Lean principles and have a true pull system, minimal setup times, little to no WIP, and a “just in time” supply system. The ideal maps have a high value-added production ratio (Cooper, Keif & Macro Jr., 2007).

Product Family: Digital Color Printing				Job Type: Business Cards		
Quantity: 250 cards		Print Specifications: Color, duplex		Finishing Specifications: 2 folds, 2 tab closures, address printing		
Seq.	Process Step	Time (Minutes)	Value-Added	Waste, but Needed (Type 1)	Waste (Type 2)	Type of Waste
1	Customer emails designer with job specifications	0.5		X		
2	Designer walks printed email to front desk to be written up as job ticket	0.1			X	Motion
3	Service employee inputs data into invoice system and prints job ticket.	1440.0		X		Waiting (work is waiting)
4	Job ticket is printed and given back to designer	0.2			X	Motion
5	Designer creates PDF from supplied Word Document	1.0	X			
6	PDF file is placed on the server for the black and white copier	0.5		X		Transport

Table 3. Excerpt of an in-depth process analysis for the digital print job in Figure 4. Format from Sayer & Williams, 2012.

Next, future state maps were created for each of the product families representing six months to a year down the road. These future state maps took advantage of areas that can be more easily improved immediately and are achievable goals, such as reducing changeover times and scheduling work to promote flow (Cooper, Keif & Macro Jr., 2007).

The final iterations of each value stream map were drawn using Adobe InDesign since the researcher is very skilled at using the software to draw complex diagrams. The example map shown in Figure 4 was drawn by the researcher in this program.

Recommendations

To accompany the current, ideal, and future value stream maps, the researcher created a written analysis documenting her findings and explaining what each map illustrates. The analysis includes a recommendation section with detailed suggestions and action plan items to help Small Printer achieve the Lean goals set forth by the future value stream maps. It includes an outline for the implementation of some of the following Lean tools:

1. Setup reduction
2. Total Productive Maintenance
3. Visual Management
4. Kaizen
5. Flow
6. 5S implementation
7. Lean culture and team building

These action items address the changes that can be made quickly and easily to get the company started as well as long-term strategies for continuous improvement and future success.

Chapter 5

Results

Overview of Existing Shop Structure

The print shop observed for this case study, referred to as Small Printer, is a small, 6-employee business. It is considered a “quick print” shop because it caters to walk-in customers and local businesses in need of small runs of printed materials. Despite its small size, the company offers a full range of print services including digital color and black and white printing, 4-color and 2-color offset lithography presses, cutting, scoring, folding, many forms of binding, full service mailing, and in-house design services.

Personnel & Departments

Like so many others, Small Printer is divided into discrete departments. Employees are trained primarily in the activities of their departments with little to no crossover. These departments are:

1. Sales and customer relations
2. Graphic design & digital color (grouped as one)
3. Black & white digital printing
4. Press
5. Binding, finishing, and mailing
6. Deliveries

The sales and customer relations department is centered around the service desk for the shop. Phone inquiries and walk-in customers are served by the owner at the front desk in the lobby area. Unfortunately, the company recently lost its service representative and while

seeking a replacement, the owner has taken over the role. In addition to handling customer questions, this department is also responsible for generating price quotes, creating job tickets, and invoicing.

The graphic design department is run by the in-house designer who handles all graphic design work, file handling, and impositioning for output. The designer is also responsible for outputting any digital color jobs to one of 3 digital color printers. The designer rarely answers the phones, but is in charge of handling the company's email account. Much of the communication with existing customers, such as job requests, quote inquiries, and design proofing, happens through this email account. Subsequently, the designer spends a sizable portion of the day fielding questions and printing emails to give to the sales department to respond to via phone or write up as jobs. If a job will be printed on one of the two presses, the designer is also responsible for operating the computer-to-plate machine.

The black and white digital color department is also overseen by a single employee. After the designer has prepared files, they pass to this employee to be printed on a high capacity digital printer. The department is also responsible for running a blueprint printer and high capacity scanner when needed.

The press department has a dedicated press operator, however, due to personal issues, this employee is no longer working full shifts. To compensate for the press operator's reduced hours, the production manager now prints many of the offset press jobs. This department has two sheetfed offset presses, one 2-color and one 4-color, that can handle up to 12" x 18" sheets. Jobs are designated to go to press rather than the digital color departments when the customer wants a spot color, when the run length reaches over 2,000, or when printing carbonless forms. Most jobs that go to press have only one to two colors and are usually run on the 4-color press since it is the newer machine.

After a job is finished it usually moves through the binding and finishing department where it can be cut, scored, folded, collated, or bound depending on the job's requirements.

The department also handles variable data printing and for the distribution of printed mailings such as newsletters and advertisements. The production manager's primary responsibility is to perform all the various finishing tasks as well as preparing mailings for shipment.

The final department is for deliveries. Any completed job that needs to be delivered is staged near the exit in preparation for one of about four daily delivery runs. When the delivery employee is not on the road, he is able to assist the production manager in performing a few of the finishing tasks.

Current System for Job Completion

The typical path for a job at Small Printer begins with the customer sending an email to the designer. Although some customers choose to call or walk-in, the majority of jobs, an estimated 55% (based on observation and employee input), start via email. An estimated 40% of jobs are initiated via phone call and the remaining 5% begin with a walk-in client. The designer reviews the email, downloads and saves any files the client attached, then prints the email and walks it to the front desk where the owner/sales rep sits. The printed email is placed on a stack of other printed emails and handwritten notes all waiting to be written up by the owner as job tickets.

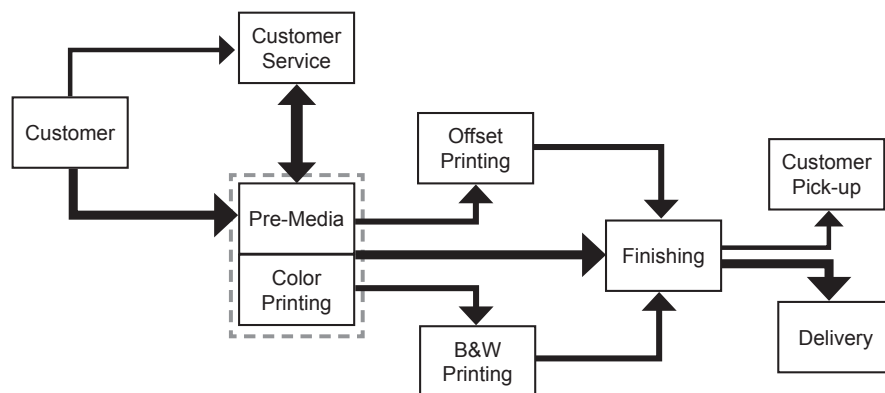


Figure 5. Flow chart showing path for job completion. Arrow thickness suggests volume. Pre-media and Color Printing are grouped together as a single department.

Standard jobs, such as business cards and simple copies have standard pricing that is documented and fairly well adhered to. Many other jobs, however, are given individual price quotes based on the client's requirements, cost of materials, and labor. These values are not documented and require the owner to handle each job personally.

Jobs are considered "written-up" when the details have been entered into the company's invoicing system and a printed job ticket is created. This "job ticket" contains limited information about the job including number of pages, how it will be printed, ink color when applicable, and general finishing requirements. Other important, standard information like sizing, paper type/weight, in-depth finishing specifications, and customer requests are mostly absent from the ticket and are communicated using supplemental hand-written notes or through verbal communication. The printed ticket is placed in a shallow box, along with any hand written notes or samples, and travels with the job through production. Once the ticket and box are ready, the box is usually given to the designer to create or handle the necessary files. No formal scheduling is in place beyond writing the due date for a given job on the job ticket.

Once the job box reaches the designer's desk, graphic design can begin. Since there is no formal scheduling system, the designer is responsible for mentally keeping track of all job due dates and for expediting jobs as needed. The extent of required design services vary greatly—some jobs need an hour of initial layout and design plus multiple rounds of proofs, while others simply involve the 1-minute operation of converting a Microsoft Word document to PDF. Files that are ready and have been approved for output then take one of three paths: digital color printing, black and white printing, or press.

If the job will be printed on a digital color printer, the designer is responsible for obtaining the paper, either by asking the production manager or owner, or personally locating it. The paper is then inserted into the proper printer tray and the proper settings are input on the menu screen. The designer sets matching print settings on the computer and the file is

printed. Once all components of the job are finished printing, the materials and job box are walked over to the production floor for finishing.

If the job will be printed in black and white (B&W), the designer puts the prepared files on the company server to be downloaded by the B&W department employee. The job box is then carried to the B&W department so the employee there knows that something needs to be printed. The B&W employee will then follow the same steps as the designer to move the job through to the next phase.

Before a job can go to press, plates must be made. The company has an automated computer to plate (CTP) machine that takes the file from the designer's computer and automatically separates the colors to create the corresponding plates. The plate material is expensive, so to help reduce mistakes the plate data is stopped at the CTP's RIP until the production manager or press operator has the time to check the file and release it to be plated. Once the plates are made, they will sit inside the job box next to the press until they are used.

As mentioned previously, the company usually uses the 4-color press, regardless of the number of colors being used. Before the job can actually be printed, the press operator must changeover the press from the previous job or set the press up for the day. Plates are hung, ink is added and the registration and ink density are adjusted using press sheets designated for reuse as make-ready. Both the press operator and the production manager adjust the press based on visual inspection of printed sheets, rather than using any equipment or making formal measurements. Once the final printed sheets come off the press, they move to the finishing area as work in progress.

The finishing department is the last stop for jobs before they go to the customer. The most commonly required finishing step is cutting and others such as scoring, folding, binding, etc. are based on each unique job's specifications. Once the finishing is complete, the job is boxed and labeled to go out for delivery or be stored for customer pickup.

Jobs are taken out on delivery periodically throughout the day or as needed. If the customer prefers to pick up their order, the owner will call to inform him or her that the job is complete. The job cycle ends when the customer receives the order and an invoice is signed and paid.

Product Families

As explained in the literature review, value stream mapping entails watching and documenting the process steps a product takes and any information flow from the customer (end) to the supplier (beginning). Before any value stream mapping (VSM) can begin it is important to select specific product families to focus on (Rother & Shook, 2009). Mapping every job would be too complicated and time consuming, particularly in a print shop.

After the initial observation period, three product families were identified for mapping in this study. They are distinguished from each other by the printing method, which are 1) Digital Color Printing, 2) Black and White Printing, and 3) Press Jobs. The jobs mapped for each family were chosen to provide insight into the three different printing methods and highlight several of the possible finishing processes.

Product Family One: Digital Color Printing

Digital color prints are the company's most common job type, comprising about 70% of jobs in a given week (based on observation and employee input). Although this job type is the most common, the size of each job (in pages printed) and the degree of required finishing is typically much less than any other product family. The types of products in this family include business cards, stationery, full-color flyers, photos, etc.

Product Family Two: Black and White Printing

This product family has the second largest average run length at around 500 pages, as it is more economical to print large volume orders in black and white than color. Smaller orders

can be printed B&W when customers request it to save on costs. B&W jobs typically require more extensive binding and finishing than those printed in color, as many of the jobs are mass-produced mailers, books or other widely distributed media.

Product Family Three: Press Jobs

Press jobs have the largest average run length at about 1,000 impressions (for this shop pages and impressions are the same). A job goes to press for one of two reasons: volume or customer specified ink colors. Jobs in this category are mainly comprised of smaller runs of business cards and marketing materials that require spot colors or metallic inks, and large runs of one color carbonless forms. Press jobs tend to have varying levels of binding and finishing required. After printing, business cards usually only need to be cut, whereas carbonless forms require extensive finishing.

Current Value Stream Maps for Small Printer

Each value stream map created for this research is a snapshot in time of how a particular job belonging to a product family is completed, and should be used together to create an image of the shop's production system. A quick print shop, like Small Printer, has a huge variety of job types moving through its production line at any given time. This variety creates a challenge when trying to map the current value stream, as it will change drastically based on each job's specifications. Additionally, overlap between processes is expected, particularly at the sales and pre-media stages prior to the job actually being printed. Since the shop is so small, a couple employees perform most of the tasks and any analysis and future maps will need to consider how all these value streams work together on a particular day.

Another challenge encountered during data collection was the unit of measure to use when collecting data for cycle times. Many steps in production are performed on the entire stack of printed papers, while others use one sheet at a time. In order to keep the data relevant

and useful to the shop owner, the researcher chose to use the entire job as the unit of measure. All cycle times are for the process to be completed for the entire run length of the job.

Data collected for five different jobs is thoroughly documented in the spreadsheets found in Appendix B. Three jobs were chosen as the best representatives for mapping the value stream of their respective product families.

Product Family One: Digital Color Printing

The job used in mapping the first product family's value stream was for 40 cocktail menus for a local restaurant. The menus were digitally printed in full color on one side, measured 4" wide by 11" tall, with full bleeds, and required only cutting from the finishing department.

The repeat customer chose to contact the designer directly via email and phone, bypassing the sales department. Once all the job details were received, the designer printed the client's email and gave it to the owner (see "Personnel and Departments" section for details about departments). After waiting 24 hours, the job request was reviewed, the large safety inventory visually checked, and the printed job ticket was given back to the designer. The designer created the menus with the customer supplied text and went through two rounds of proofs via email before receiving approval to print.

For the purpose of creating the current value stream maps, pre-media is included in the lead and value-added times. Time is considered value-added when it is spent directly transforming the raw materials in some way. The time the designer spends performing layout and revisions to the document are considered value-added, while all other time is not. The researcher made this choice because the current structure requires all jobs to pass through the pre-media department.

The designer in pre-media is also responsible for all digital color printing. Once the job was impositioned and ready for output, the designer spent time locating the paper. In an

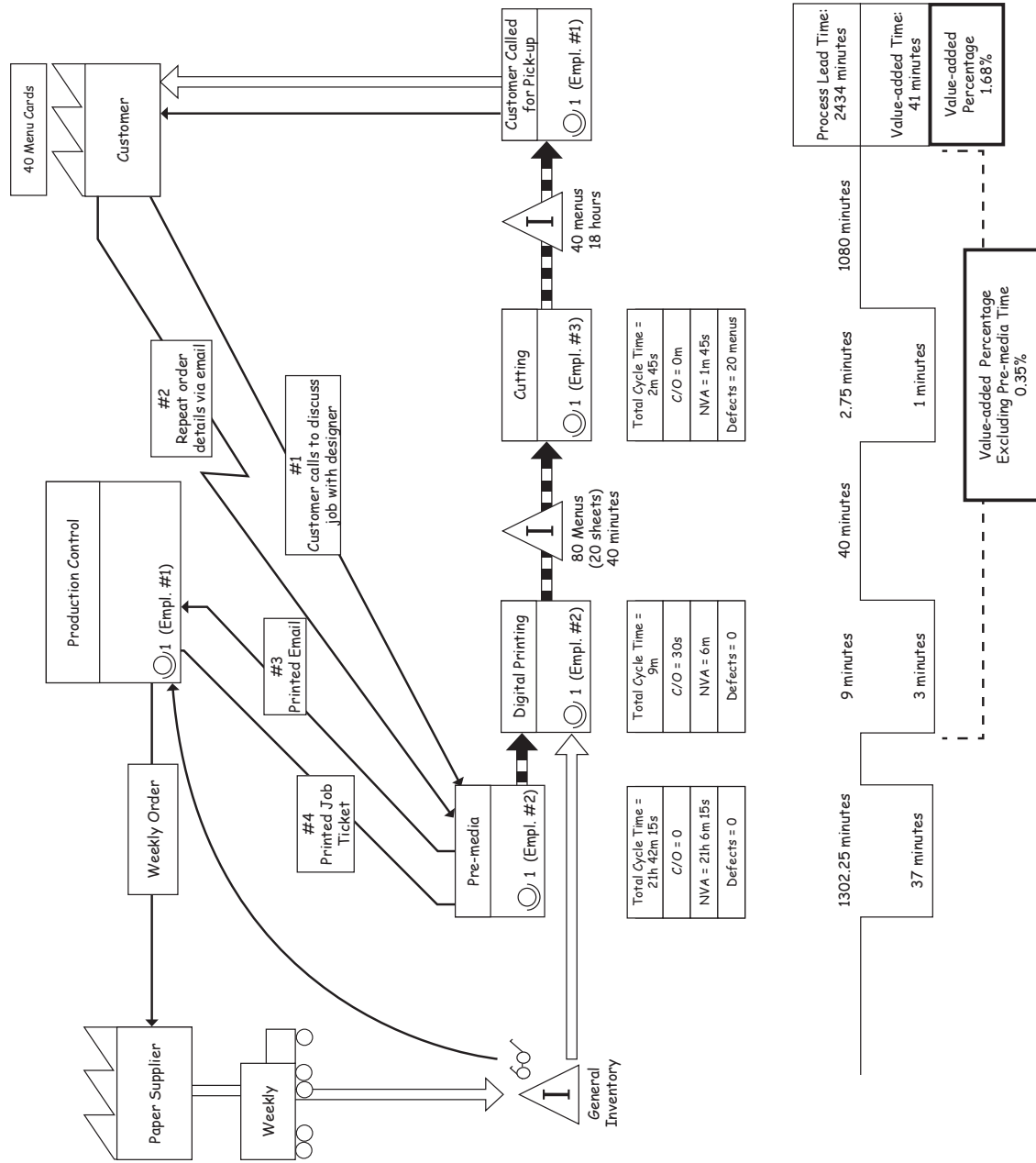


Figure 6. Current value stream map for product family 1: digital color printing.

attempt to use up old stock, the wrong paper size was used for output. This resulted in half of the menus being unusable due to image cropping.

After printing, the stack of menus was transported to the cutting area where they waited 40 minutes to be cut. This is where push first appears in the value stream. The job was released from pre-media regardless of the availability of downstream processes. This resulted in WIP while the finishing department arranged time to cut the job. The cut cards were then boxed and taken to the front desk where they waited overnight for the sales department to inform the client that the order was ready for pickup.

Due to the long wait during the proofing step and the overnight wait before the customer was called, the process lead-time was 2,434 minutes with a value-added time of only 41 minutes. The result is a value-added percentage of only 1.68%. As an added bit of information, the researcher also calculated the value-added ratio if pre-media is not included in the value stream. This resulted in a reduced VA percentage of only 0.35%. Although this finding may seem surprising, very low value-added percentages are common in current state maps that have the traditional push system (Cooper, Keif, & Macro Jr., 2007).

Product Family Two: Black and White Printing

The job used in mapping the Black and White product family's value stream was for 250 monthly mailers for a local organization. Each mailer was comprised of two sheets, one 11"x17" and one 8.5"x11", both printed in black and white on both sides. During finishing the 11"x17" was folded in half and the smaller sheet was inserted inside. The collated sheets were then folded in half and closed with two plastic tabs (required by the post office). Addresses of the recipients were printed on each mailer before being delivered to the post office.

This map is similar to the first product family's in that the client bypassed production control with the order. The job was released quickly from pre-media since it was a repeat job and the push sequence began. After being printed, the job was pushed to the finishing

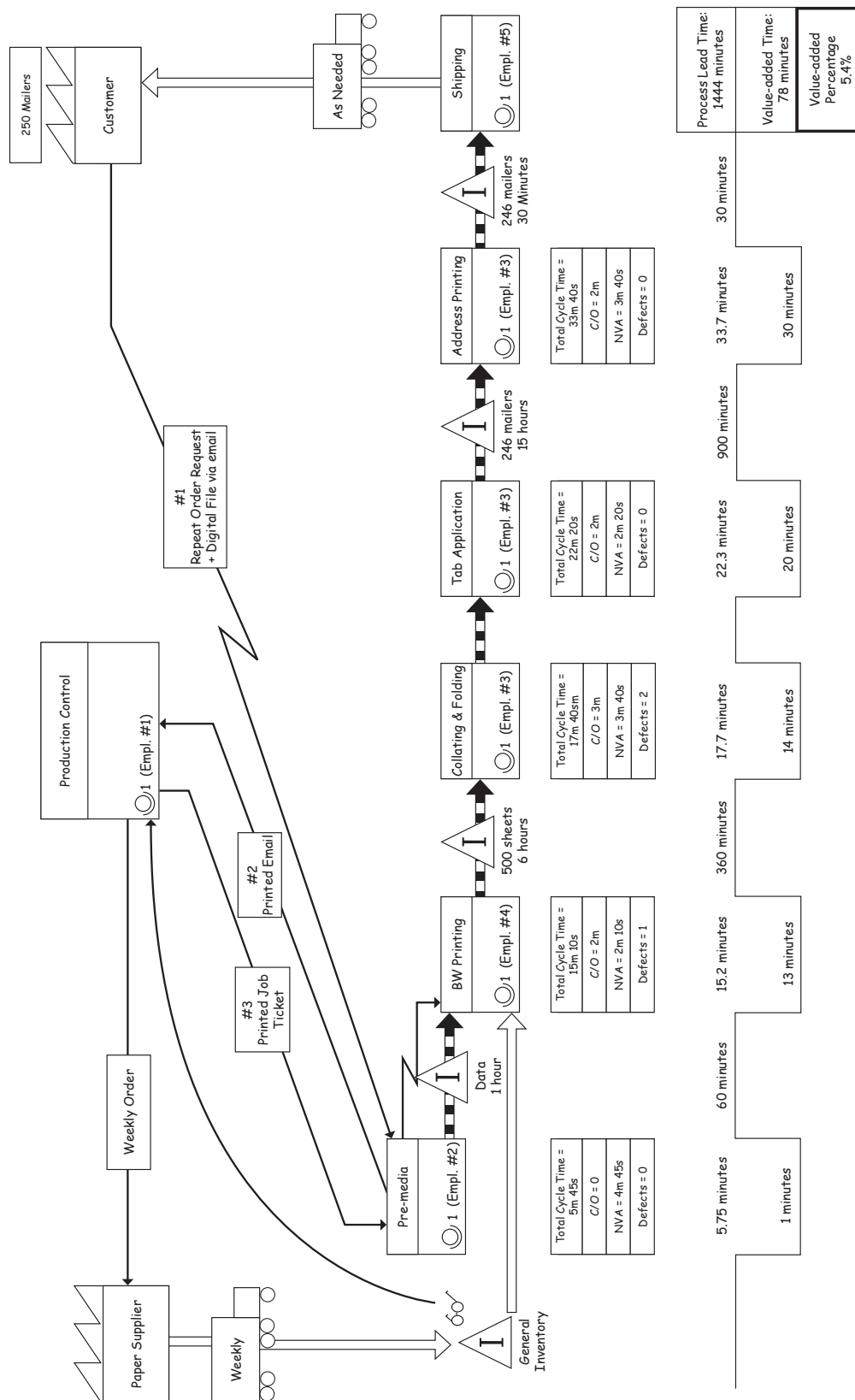


Figure 7. Current value stream map for product family 2: digital black and white printing.

department, where it sat as WIP waiting to be turned into mailers. The production manager was solely responsible for each finishing step and had to juggle this job with others entering the finishing area. The collating and folding steps were completed toward the end of the workday, and the address printing had to wait for the next available time. Unlike the first map, the delivery employee delivered this job to the post office.

The large amount of WIP wait time resulted in a long lead-time of 1,444 minutes with only 78 minutes of value-added time. The percentage of VA time is 5.4%. This is better than Product Family One, but still not optimal.

Product Family Three: Press Jobs

The job used to map the Press product family's value stream was for 10 books of receipt style tickets for a local auto dealer. Each book contained 100 carbonless forms (2 pages each) for a total run length of 2,000 pages. After printing, the forms were padded, perforated three times, and the top form was numbered four times with a unique code.

Unlike the previous maps, the client for this job did contact the sales department/owner to place the order. Since this was also a repeat job, the designer was able to quickly send the files to the CTP machine's RIP. There they became WIP and waited for the production manager's approval before permitting the CTP machine to create them. The finished plates waited near the press until the previous job was completed. After another waiting period, the job was printed on the press. The value stream map shows the changeover time for the press was about equal to the actual run time.

Once printed, the loose sheets waited to be padded by the delivery employee who sometimes helps with production. The padding step requires a long wait time while the glue dries between coats and introduces non-value-added time that may or may not have been avoidable. The dry pads were perforated, numbered and bound by the production manager, then staged in the delivery area overnight while waiting for the delivery employee.

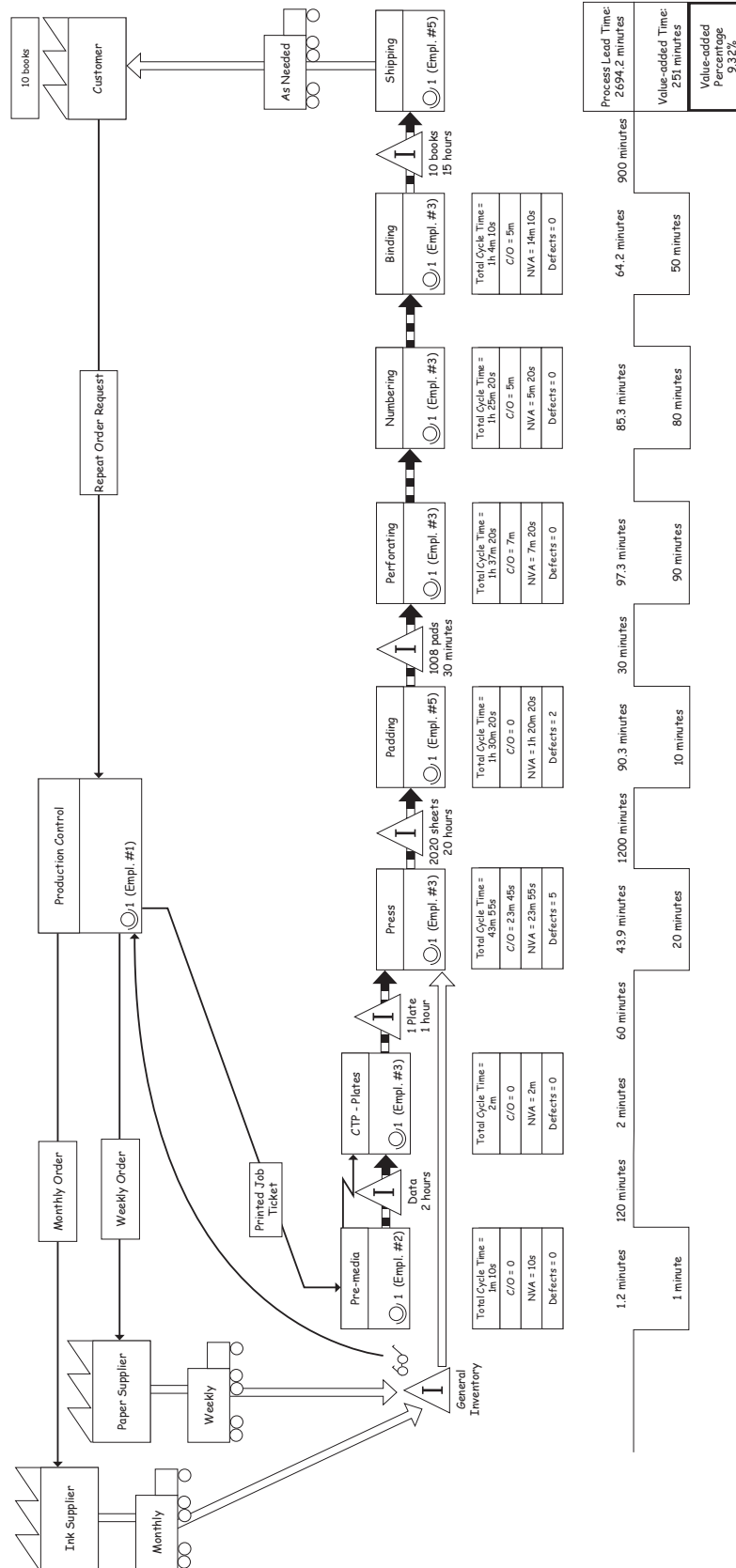


Figure 8. Current value stream map for product family 3: Offset Press

The total lead-time for this job was 2,694.2 minutes with total value-added time of 251 minutes. The percentage of value-added time was 9.32%—quite a bit higher than the previous two jobs.

Assessment of Waste

Although it is not usually recommended to attempt mapping an entire shop floor, the researcher chose to create a high level diagram using the VSM symbols to show how the current system was operating as a whole. The map shown in Figure 9 shows a combination of the findings from the three product family maps.

Beginning a Job

In many cases, the value stream starts with the customer bypassing production planning entirely by directly contacting the designer through email. The designer then becomes the intermediary between the sales department and the customer, consuming a large portion of the designer's valuable, saleable time. This could be considered type-1 muda, or waste that is non-value-added, but deemed necessary for the time being. Printed job requests are added to a stack at the front desk and wait to be responded to or written up as job tickets.

The shop recently lost its full-time service representative and as a result, the owner has taken over both the sales and production control roles. The researcher observed that the owner has become overburdened with front-end tasks like answering phones, invoicing clients, and serving walk-ins while still retaining regular, managerial, production control and accounting duties. *Muri* is the Lean term for the unnecessary or unreasonable overburdening that is plaguing the shop's owner and can be physically harmful as well as detrimental to the system. It has caused a backlog of jobs to be written up, delaying jobs hours or days before entering production. Additionally, there is no formal regulating or scheduling of jobs entering the workflow, leaving it up to each individual department to expedite as needed to meet job deadlines.

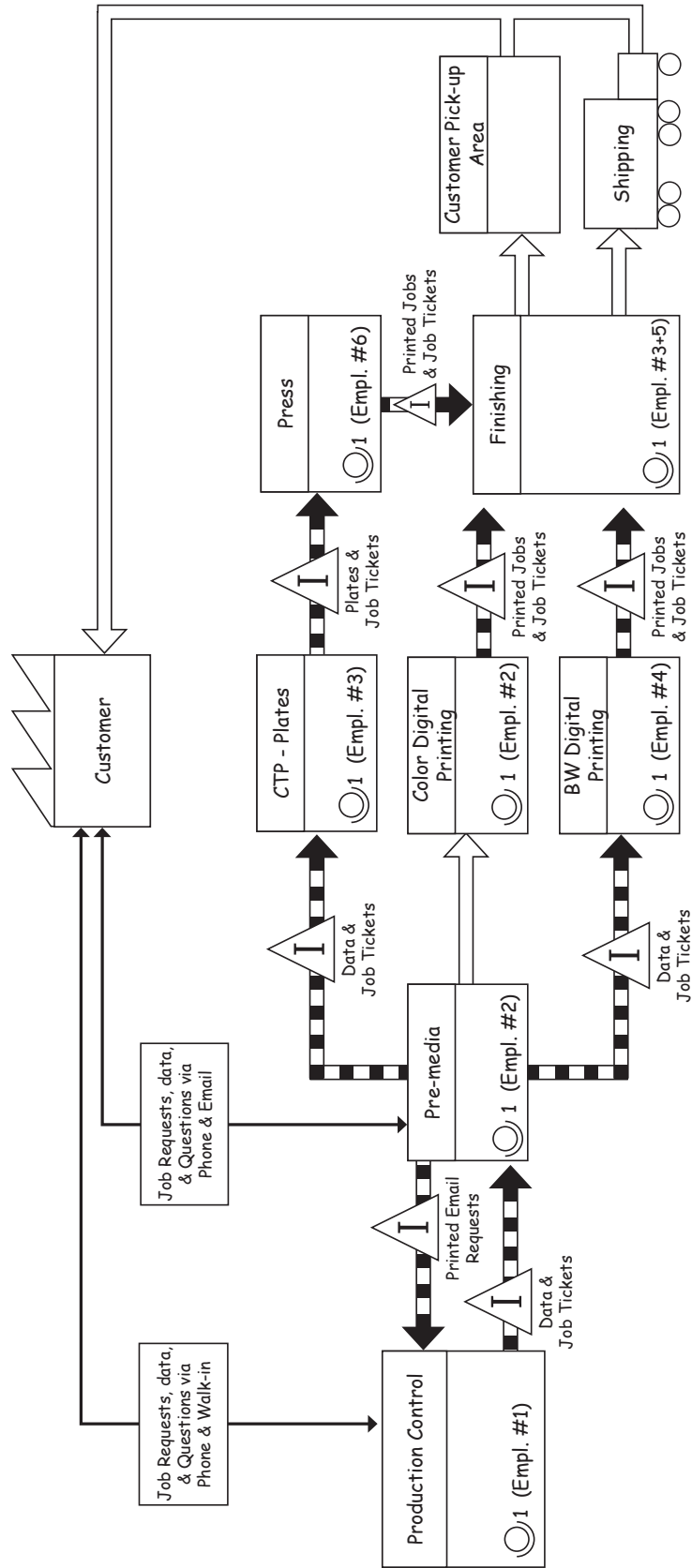


Figure 9. Current value stream map for the overall shop.

Bottlenecks

It becomes immediately evident when looking at the overall shop map in Figure 9 that there are two primary areas where the system bottlenecks: pre-media and finishing.

The lack of proper scheduling and timely job ticket creation result in a huge bottleneck at the pre-media stage putting pressure on the designer to release jobs as quickly as possible for output. Jobs are released from pre-media without any scheduling or indication that downstream processes are prepared to receive product. Subsequently, the push system starts in pre-media and largely influences the amount of WIP that piles up between processes. Remember from Chapter 2, work-in-progress (WIP) is waste because it ties up valuable space, capital, and energy to move and store. It is also a symptom of larger problems within the value stream. Acting as the intermediary, the sole file handler, and the initial scheduler/expediter of jobs leads to overburdening of the designer.

Once printed, all jobs funnel back into the finishing department—the second bottleneck. Since finishing is the most labor-intensive step and only has one dedicated employee, jobs typically get stuck waiting for their turn. The researcher observed that expediting usually occurs at this step as more urgent jobs are pushed to the front of the line and others are continually postponed. With the added responsibility of operating the press, there is growing pressure on the production manager to perform many tasks quickly in order to meet job deadlines. This can sometimes result in defects and overproduction to compensate, and always results in excess waiting, transport of WIP, inventory, and motion as the production manager tries to stay ahead—six of the seven forms of waste in Lean manufacturing. Like the owner and designer, the production manager is overburdened by the pressure to perform above capacity. It is important to mention that the waste is not the fault of the production manager, but rather a product of the push system that is traditional in Western manufacturing.

Inventory and Organization

Common in the printing industry is the belief that keeping medium to large amounts of paper and supplies on hand is a good practice. This stems from the traditional, inflexible relationship between suppliers and printers as well as fear of not having the stock on hand when a big job comes along. In Lean, these inventories are called safety buffers and are considered a form of waste. Small Printer has a fairly large amount of safety stock, which includes a couple hundred varieties of paper to choose from. Much of the inventory, particularly the large selection of specialty papers, has been collected over the past decade as remnants from past jobs. There is currently no system in place for managing this accumulated paper or for keeping track of in-house quantities. When paper is needed, it must be found amongst the stacks, reams, and cases.

The large inventory maintained at Small Printer is immediately evident when entering the shop. Paper is stacked on the floor, on carts, and on most available surfaces, taking up valuable workspace. Near the presses and the back door, only a narrow path is left between the walls of paper reams. Rework and overproduced items (waste) from past jobs is frequently kept and sits near the machine that last worked on it.

It is apparent that the shop is generally disorganized. Individual employees do their best to keep their personal work areas tidy, but the disorganization of shared spaces is slowly encroaching on them.

In addition to being waste, the inventory is cluttering the shop causing more waste in the form of motion, transport, and waiting. Employees have to work around the inventory, leading to increased, unnecessary motion, as well as transporting the inventory when the space is needed. Not only is the inventory itself in a constant state of waiting to be used, the employees often spend time “waiting” trying to find the correct paper for a job.

Communication, Scheduling, and Job Tickets

Job boxes are used to contain the job ticket and any notes or samples as the orders travel through production. All other communication within the existing system is verbal. The invoicing system used to create job tickets is not currently configured to easily identify all active jobs, and there is no way to track what phase of production a job is currently in. The researcher observed one job go “missing” because the job ticket was misplaced and no one knew if the job had been completed and delivered. Unfortunately, the researcher was unable to observe how the situation was resolved.

Since most of the communication within the shop is verbal, employees end up repeating the same set of instructions several times for any given job. No formal scheduling system is in place to manage the order or timing of production. Jobs complete each step of production when the responsible employee has the opportunity to perform the necessary steps. Each department determines its own schedule based on the jobs currently waiting for processing. During the observation period, the researcher noted that these factors seem to contribute to a stressful work environment.

Although the somewhat disconnected flow of information can cause waste to occur throughout the value stream, it alludes to a problem more significant than one of the seven wastes. Respect for people is fundamental to Lean and relies heavily on good communication as well as engagement and empowerment. Poor communication is ultimately a root cause of all waste within a company and hinders the problem solving necessary to eliminate it.

Overproduction

A more subtle issue that is seen more in the tables used in data collection (see Appendix B) is the overproduction of jobs to create buffers in the value stream. For example, data collected for the Digital Color Printing product family shows twice as many menus were printed than needed. This was to account for losing half the cards as a result of printing on

paper that was too small. Overproduction is not an uncommon practice in print shops, but its prevalence does not make it correct. Having standardized work, cleaner workspaces, counts management, and the right materials and tools on hand will reduce the need for wasteful overproduction.

The tools and concepts presented in the Chapter 2 will be used in the next section to discuss methods for restructuring the value stream to create a true pull system, reduce lead times, improve flow, and increase the VA percentage.

Chapter 6

Summary and Recommendations

Summary

The current value stream maps depict the norm in a quick print shop, where there are many jobs with very different specifications moving through production simultaneously. The three current state maps can be used together to highlight larger issues within the overall value stream. The current overall shop map in Figure 9 shows the high-level commonalities across all product families to be addressed before the smaller details specific to each job.

Analysis of the current state value stream maps and observation of Small Printer revealed six key areas for the company to address that will provide the greatest benefit toward becoming Lean. The areas are: company culture, organization, bottlenecks, scheduling, communication and inventory. The company culture and organization are both foundational to starting any Lean initiative. Kaizen events will help jumpstart these changes and help the team gain momentum to tackle the more complicated aspects of the value stream.

Improving the value stream will take time and in the spirit of Kaizen will never be finished. Small Printer can take advantage of “low-hanging fruit” in the beginning stages to lay the foundation for a pull system. Bottlenecks can be addressed by restructuring work areas, shifting customers’ initial point of contact to production control, and cross training employees. The primary goal for scheduling will be to level the mix and volume of jobs sent to each department and establish finishing as the pacemaker process. Once a pacemaker has been established, a pull system can be created using supermarkets and kanbans. Communication can be improved using the existing scheduling software within the shop and designing visual

management boards to track jobs in production. Lastly, inventory must be reduced and suppliers found who are willing to make frequent or “just in time” deliveries to meet the shop’s daily needs.

The following section outlines changes to the six focus areas that will improve the overall value stream and provide direction in achieving the ideal Lean state. These changes are represented in the future and ideal state value stream maps for each product family shown in Figures 11-16 and the overall map for the shop in Figure 10.

Area	Problem	Recommendations
Company Culture	Disconnected, does not encourage innovation, owner micromanages, trust issues	Daily demonstration of trust, allowing employees to make decisions, encouraging new solutions, Kaizen events
Organization	Disorganized shop, accumulation of rework, scrap and materials, clutter	Kaizen events for 5S and daily department inspections
Bottlenecks	All jobs must pass through pre-media and finishing, creating WIP and push.	Move pre-media inline with sales, merge digital printing departments, make finishing the pacemaker
Scheduling	No formal scheduling system. Push creates large WIP and overburdening.	Establish kanbans and supermarkets for pull using finishing as pacemaker. Production control levels mix and volume.
Communication	Clients bypass production control. No job tracking system.	Establish sales department to handle customers. Create visual management system. Utilize existing software functionality.
Inventory	Huge safety stock. Inflexible relationships with suppliers.	Reduce safety stock over time. Negotiate or find new suppliers. Overcome fear.

Table 4. Summary table of problems in key areas and recommendations for improvement

Building the Foundation

Before beginning any Lean initiative, Small Printer will need to build the foundations for transformation within the company. The owner must be well educated on Lean principles and tools and be fully committed to investing the time and resources required to create long-term change. Without the full, unwavering dedication of upper management, the organization

will not maintain the changes required to be Lean. All 6 employees must also be educated on Lean principles and fundamentals. With such a small shop, it is best to have all staff members on the same team for Kaizen events and daily Lean meetings. Mini teams of two could be formed, for example with the production manager and delivery employee, to focus on issues in particular areas and develop work cells. Lean is not just a set of rules or suggestions for doing things better, it is a fundamental change in thinking across the entire business that is practiced every moment of the day.

Company Culture

The existing management structure is currently quite flat. All employees report directly to the owner. The production manager is in charge of daily production activities while the owner deals with customers, takes orders and puts out fires as they arise. The flat structure will help facilitate the flow of ideas within the organization, but it will not be enough to leave things as they are. The Owner will need to work everyday at encouraging and developing the culture of Lean. Employees should be made responsible for quality and given the authority to make changes to achieve it. Employees should be encouraged to innovate each day and rewarded for proposing solutions that improve the value stream and the working conditions of the shop. Visual boards can help track and acknowledge these contributions. The owner must be open and willing to accept this involvement in the shop's management and work on becoming comfortable relinquishing some control.

During the researcher's short observations it became apparent that the owner likes to micromanage, which causes slow downs in the system. Delegating tasks and trusting employees will go a long way to creating a smoother work environment and empowering everyone.

Although it would require a financial investment, it may be advisable for the shop to hire a consultant to help with designing and executing a training and education program for every member of the shop, including the owner. The consultant can act as an unbiased

third party to keep each person on track and point out behavioral problems as they arise. For example, it may be critical to have someone stop the owner when micromanaging tendencies start to resurface or when employees become defensive of their current operating methods at Kaizen events.

Organization: A Need for 5S

Once the culture is beginning to form, the next biggest obstacle will be to perform 5S. Kaizen events are a great way to jumpstart the team mentality and working together to improve the workplace is an excellent place to start. It helps create the sense of a new beginning for the organization and sets the stage for further change.

Production control and sales (currently merged), both the owner's domain, would be a perfect place to focus the first Kaizen event for 5S. The front end of the shop is in desperate need of an organizational system for managing active and past job tickets, invoices, and quote requests. Allowing the employees to help address the issues closest to the owner will show everyone that the owner is completely committed to the transformation. The owner must lead by example before expecting others to change. Since the front desk is the first thing the customer sees and is the point of control for the system, it must be thoroughly set in order and systematized, or the rest of the stream will be set up for failure.

The rest of the shop is also currently quite disorganized and would require a 5S Kaizen event for each work area. All employees would need to agree upon standard organizational methods for storage locations, methods and any color-coding. Visual organization will be critical, particularly in areas that require tools to perform tasks such as the press. The years of accumulated make-ready paper will need disposal. The owner will also have to trust employee judgment on what items are truly needed. During observation the researcher noted that often employees want to discard something but the owner wants to keep it. This may be a perfect reason for the company to bring in an outside specialist to help mediate between the owner

and the staff. The employees also have varying levels of organizational skills and would benefit greatly from training from an outside source.

Daily checklists for performing regular maintenance, cleaning and straightening of any area will help remind each person what his or her duties are. To keep individuals accountable, the entire team should walk the production floor for a routine inspection. This gives employees a chance to be recognized for their efforts and may even breed a friendly cleanliness competition.

Kaizen events will also be critical in accomplishing the fifth S—sustain. Once the entire shop has undergone its first Kaizen it will be time to start back at the beginning. Kaizen is after all the philosophy of continuous improvement.

Once the foundation for Lean is underway, the team could begin looking for ways to reduce waste and improve flow in the value stream.

Becoming Lean

Bottlenecks and Push

The most obvious issue with the current value streams is the push occurring as a result of processes following independent schedules and working at different paces. This leads to significant WIP inventory between steps that may wait for a day or more before moving to the next step. WIP takes up valuable working space on the production floor, increases risk of rework due to damage, ties up capital and increases lead-time.

When looking at the current state maps for Small Printer, it becomes apparent that there are two primary areas where bottlenecks occur: pre-media and finishing. Although adding additional employees to these stages might help move jobs faster, the concept of Lean is to do more with what you already have. So, these two bottlenecks will need to be resolved.

Cross-training the existing employees will be absolutely necessary for a small shop to adopt Lean. Currently, the departments are divided by the three print types—digital color, digital black and white, and offset press with finishing as the fourth major department. Each print department has one employee who sticks primarily to his or her area, regardless of available work.

The digital color department is run by the graphic designer, who is also responsible for preparing every file prior to output. Much of the designer's day is consumed by printer setup and paper acquisition.

The digital black and white department's operator is responsible for running the high capacity black and white printer, the blueprint plotter, and the high capacity scanner. Despite having the second longest run length within the shop, the uptime for the equipment in the department is estimated to be between 50-65%. When not running jobs, the B&W department operator waits for work. The researcher proposes that this employee would be best utilized by being cross-trained to manage the color printers. A system is already in place to easily transfer files from the graphic designer to other employees in the shop, so beyond initial training, this would not be a difficult extension.

Customers are willing to pay for the designer's time and see it as very much a part of the value received by hiring Small Printer. The graphic design department is also one of the two bottlenecks within the system. The time spent managing the color printers is unnecessarily wasted and should be turned into billable, value-added time. Merging the color and black and white printing would better utilize the existing staff in both departments.

Merging all digital color printing will also allow the removal of graphic design from the beginning of the push system. In the current value stream, work is released into the value stream as soon as the graphic designer finishes preparing the files for output, regardless of the needs of downstream processes. When files are prepared quickly, too much work enters the value stream and overloads the production system. Conversely, when jobs take a long time to

get client approval (multiple rounds of proofs and slow response times) the production stream is stalled while waiting for work to filter down. If the value stream maps were restructured to put the graphic designer's process closer to the customer, files ready for output could flow through production control before entering the production. Scheduling would become the responsibility of production control rather than the product of the design process's speed. This would allow production control (in this case the owner) to level the load and volume of jobs being released to the production floor and help prevent push within the system.

The second bottleneck is occurring at the finishing stage. The huge variety of binding and finishing options offered is both a strength and weakness for Small Printer. Finishing is the responsibility of the production manager who receives occasional help from the delivery employee. Together they handle almost every job that moves through production. Some jobs, like the carbonless forms diagramed in Figures 8, 15 and 16 require several finishing steps, while others, like the menus in Figure 6, 11 and 12 only require cutting. To alleviate the backlog of jobs waiting to move through this department, the binding and finishing department must become the pacemaker process.

Scheduling: Pacemaker and Pull

As the pacemaker process, finishing would become the only step that receives scheduling. All upstream processes will produce based on the needs of the pacemaker, which are signaled using kanbans. Thus, the finishing department will set the pace for the entire shop. To speed the flow of jobs through the value stream, Small Printer will need to hold Kaizen events to perform 5S, initiate setup reduction programs and develop a visual management system. Cross-training the delivery employee to autonomously perform more finishing tasks will better utilize the existing human resource and improve speed and flow within the department.

All processes downstream from the pacemaker must have continuous flow. Because there is currently only one dedicated employee for the finishing department tasks, the first step in the finishing required for a job will become this process. FIFO lanes will supply all subsequent tasks within the department. Either the production manager or the delivery employee will complete each remaining step until the job is complete and staged for shipping. If the maximum number of jobs permitted in the FIFO line is reached, the upstream processes must stop to allow the finishing step to catch up.

All processes upstream from the pacemaker will have supermarkets and kanban signals. Supermarkets will allow the printing departments to produce when signaled by the appropriate finishing steps that are scheduled for the job.

Communication

Another major issue with the current value stream is the flow of communication. Customers are directly contacting the graphic designer who then acts as an intermediary between the sales department and the client. This also consumes the graphic designer's valuable time and greatly extends the lead-time for jobs. By simply making it the sales department's job to handle incoming emailed job requests, clients would get quicker feedback on quotes and specifics of the job can be discussed prior to involving the designer. As mentioned in Chapter 5, the company recently lost its sales department representative and is searching for a replacement. This individual would assume the responsibility of taking orders, giving quotes, and dealing with walk in customers, freeing up the owner to perform the critical role of production control.

There is currently little communication between production control and the departments regarding jobs currently on the shop floor. No formal scheduling or job tracking system is in place, leaving expediting up to the employees. Jobs also occasionally become misplaced or overlooked until the customer calls to inquire.

The software package the company is currently using for invoicing has the functionality to track jobs and schedules. Training will likely be required to train employees to use this tool to improve communication. Visual display boards can be designed to track jobs through production and allow fast communication of timing and specification information.

An effective method for displaying scheduling information throughout the shop would be to install 'schedule screens.' Simple flat screen televisions hung in key areas of the shop can show the visual representation of the shop and where each job is located within production. These screens could also be used to implement the kanban system to signal upstream processes to produce.

To also address issues of communication and scheduling between employees and departments, 20- to 30-minute meetings can be held every morning. These meetings would bring everyone together to discuss the day's jobs, potential workflow issues, and goals for the shift. A brief discussion every day would ensure all staff are on the same page and are working toward the same goals during production for the day.

Inventory

Inventory is checked and managed on a "go see" system and orders are placed with suppliers based visual inspection and past experience. The large inventory described in Chapter 5 will need to be reduced to not only improve the shops organization and free up capital, but also to expose problems within the value stream.

Reducing or eliminating safety stock may be one of the scariest Lean practices for a company to implement. Without excess inventory, problems or mistakes within the production system will have real consequences in the form of lost time. In a Lean facility, the time spent waiting for stock replenishment is used to identify and address the root problem so it does not return.

Safety stocks should be reduced over time as the pull and flow of the value stream improves. Relationships with suppliers will not transform overnight either. Becoming Lean requires just in time delivery of stock to meet the production needs of the system on any given day. Companies that are able to have little to no buffer inventory generally receive one or multiple daily deliveries based on the day's scheduled jobs. Having one or two daily deliveries allows the flexibility to quickly change production to meet a change in customer demand. The deliveries will generally be "less than truckload" meaning smaller quantities than are normally ordered. If the company can find one or two vendors to supply all required materials, the time spent dealing with deliveries, placing orders and organizing inventory can be greatly lowered.

This concept is frightening to shop owners who are accustomed to buying large orders to receive per unit discounts. However, in a Lean organization, this additional cost is far offset by the gains in man-hours, floor space, and free capital that can be used to add production capacity.

Small Printer will need to search for and cultivate relationships with suppliers who also embrace Lean principles and are willing to accommodate the shop's needs. These suppliers may not be the ones currently doing business with the shop.

Detailed Analysis and Explanation of Future and Ideal States

Product Family One: Digital Color Printing

Ideal State Map. All ideal state maps show the pre-media department closer to the customer at the beginning of the value stream. An official sales department has also been added to handle quotes, creating job tickets, and invoicing. Eventually, Small Printer will find and train a new member of its team to fill this position. With the addition of a dedicated sales department the owner will be free to perform the managerial tasks required to facilitate a Lean value stream, particularly scheduling and load leveling. When a job has been approved for output by

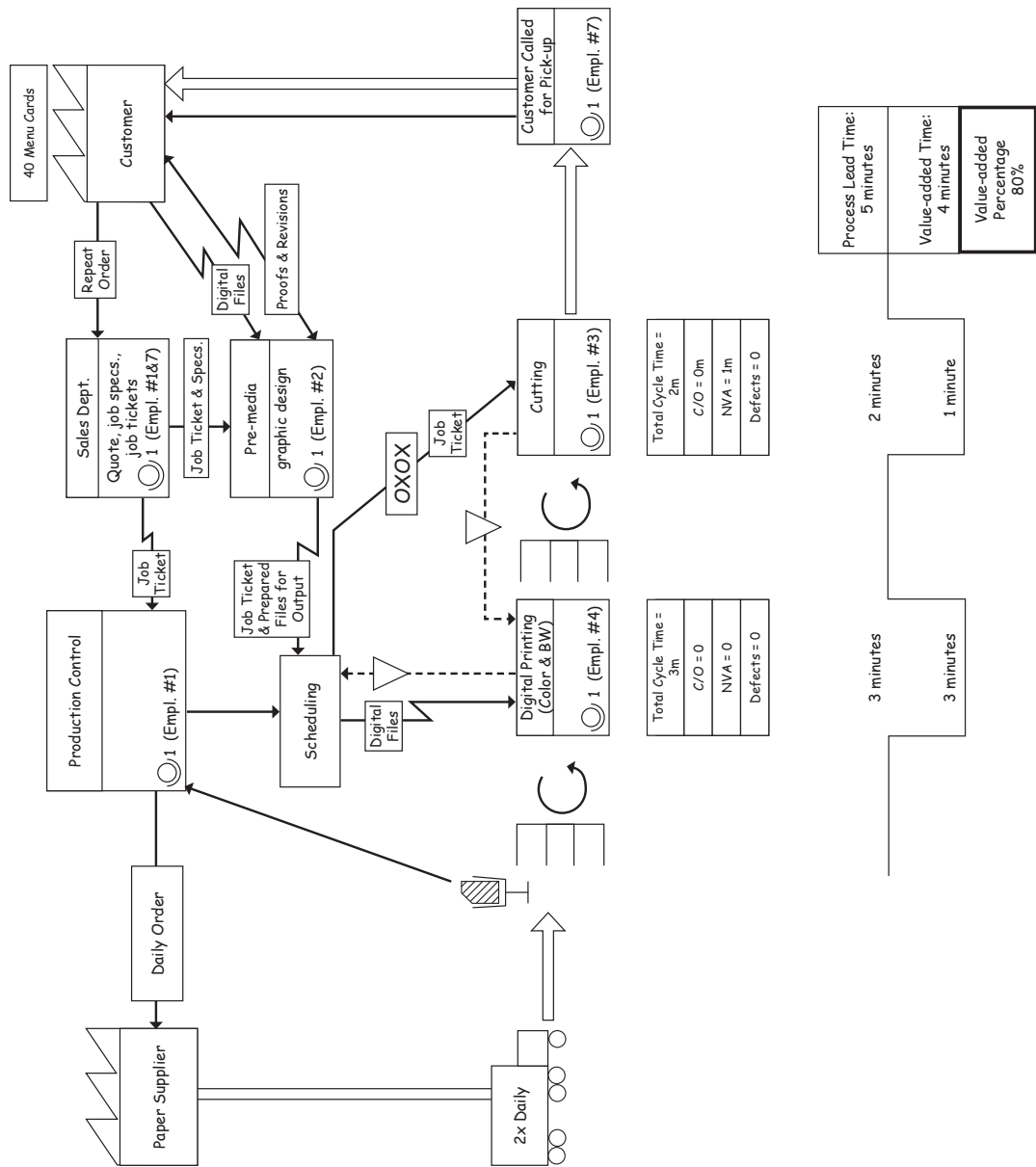


Figure 11. Ideal value stream map for product family 1: digital color printing

the client it will travel to be scheduled by production control rather than being immediately released into production.

The finishing process has been established as the pacemaker for the value stream and as such is the only step that will receive scheduling. When the production manager is ready for the job, a kanban signal will be sent to the newly merged digital printing department to run a job given to it by production control. Since each job has different finishing steps, having the production manager be the point of scheduling allows him or her to make sure the pull is not initiated until he or she has the ability to create continuous flow until the job is finished. Inventory buffers have been eliminated and the withdrawal of stock triggers a kanban station to signal need for replenishment.

By eliminating WIP inventory and creating pull, the value-added percentage is estimated to be 80%—a huge improvement to the current percentage of 1.68%.

Future State Map. The future state map for all three product families shows a goal for the company to reach 6-8 months into its Lean transformation. Because training a new employee to be fully in charge of sales may take longer than 6 months, it is not shown on the future state map. What has changed, however, is the first point of contact the customer has when placing the order. In this map, the owner (production control) is in charge of managing the email system, freeing up time for the designer.

A kanban system, similar to the ideal state, is illustrated between cutting, digital printing, and pre-media. Notice the color and black and white processes are now merged into one cell. Inventory is not completely eliminated and is shown with the safety buffer icon, but it is expected that bi-weekly deliveries should be possible within this time frame.

The formal scheduling system is not yet established and jobs that are pulled from pre-media are not expected to be leveled. It's likely that the designer will continue to try expediting jobs in lieu of proper scheduling. It may be possible to set up an interim scheduling system that

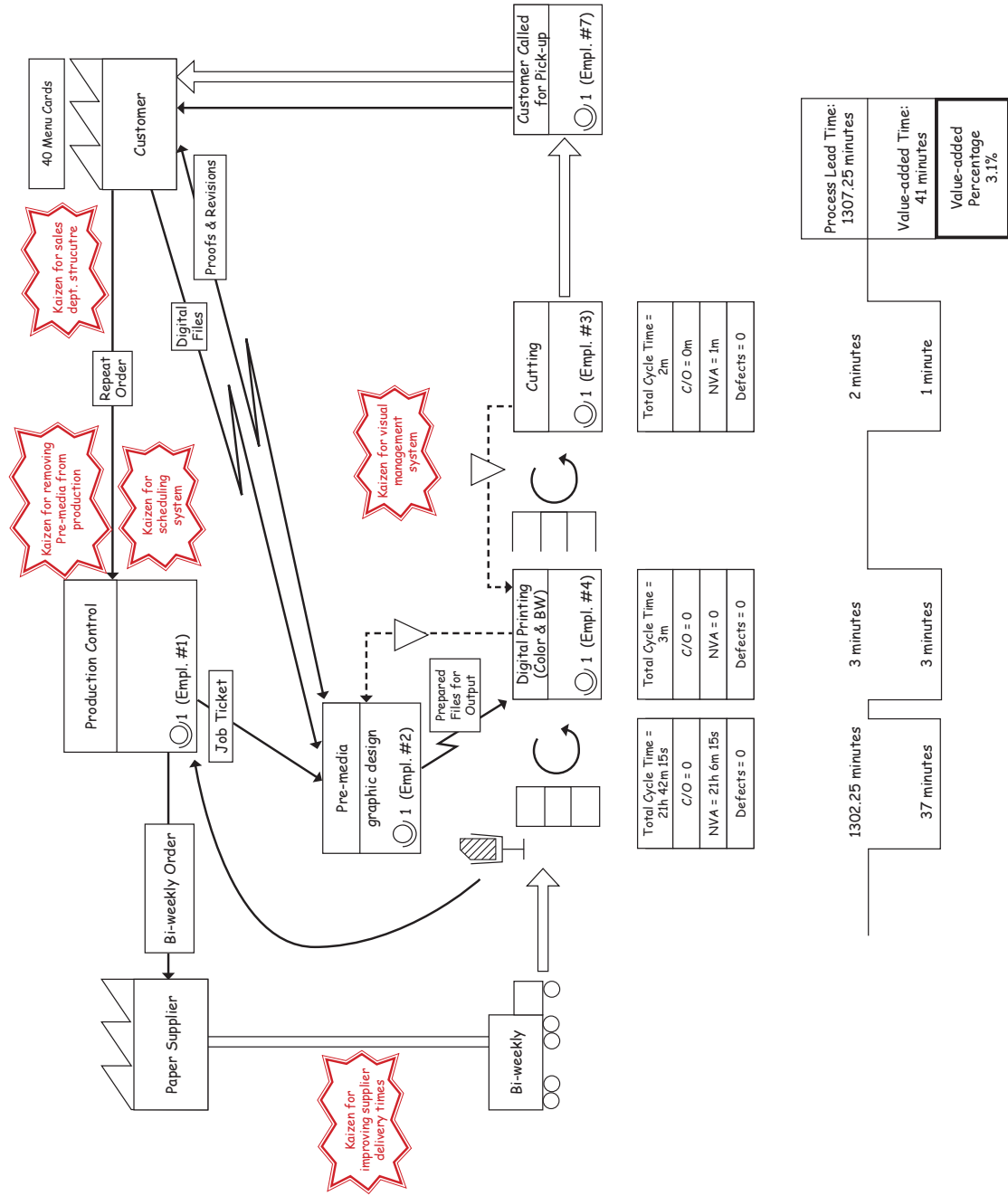


Figure 12. Future state value stream map for product family 1: digital color printing

allows quick visual indication of job priority and stage. Something as simple as a large cork bulletin board could suffice.

Kaizen bursts are placed in areas that would benefit from a team Kaizen event to make improvements like reducing setup times and creating a visual management system.

Product Family Two: Digital Black and White Printing

Ideal State Map. Black and white jobs tend to have more extensive finishing requirements than those printed in color, making this family perfect for exploring Lean options for improving the finishing processes. In this map, a production cell has been created, operated by the production manager and the cross-trained delivery employee. The two work together to collate, fold, tab, and address the mailers in a continuous chain. Rather than waiting for the entire batch to be finished before starting the next step, small quantities of printed product can be moved through the stages of the cell so they can be done with a shorter overall cycle time. Estimates for the improved cycle times put the value-added percentage at 99.1%.

Future State Map. The future state for black and white printing shows a value stream layout similar to that of digital color printing until the product reaches the collating step. As the first step in the overall pacemaker process, collating and folding would signal upstream production to begin the pull. After this process step, the value stream maintains continuous flow with the use of FIFO lanes. If both the production manager and delivery person work together, they can create flow from one step to the next. Kaizen bursts for this map show additional focus is needed on setup reduction for each machine and the creation of a production cell.

Product Family Three: Press Jobs

Ideal State Map. The ideal state for press jobs is a bit different from the previous two maps. Press jobs require plates to be made that were traditionally created by the graphic designer in

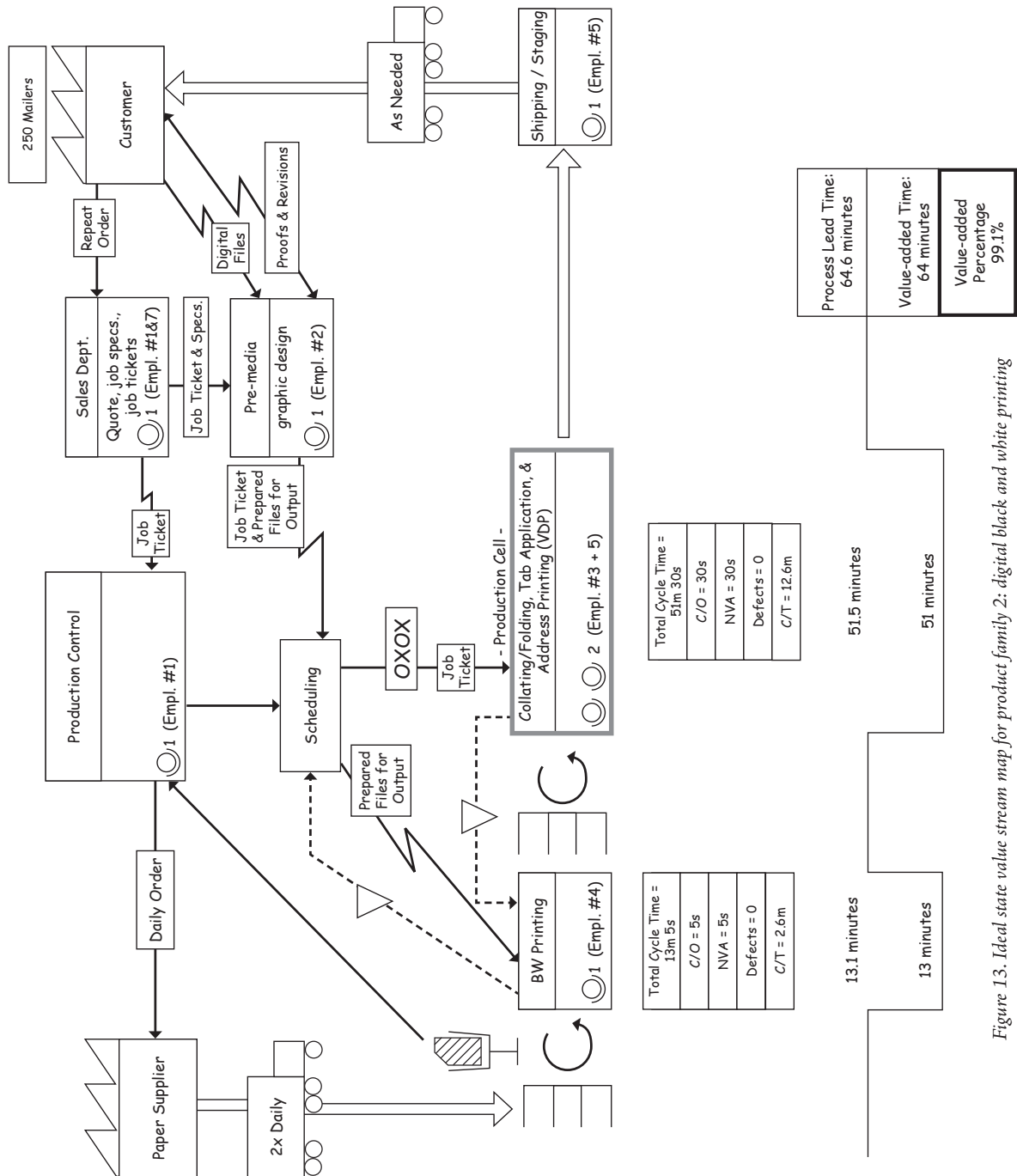


Figure 13. Ideal state value stream map for product family 2: digital black and white printing

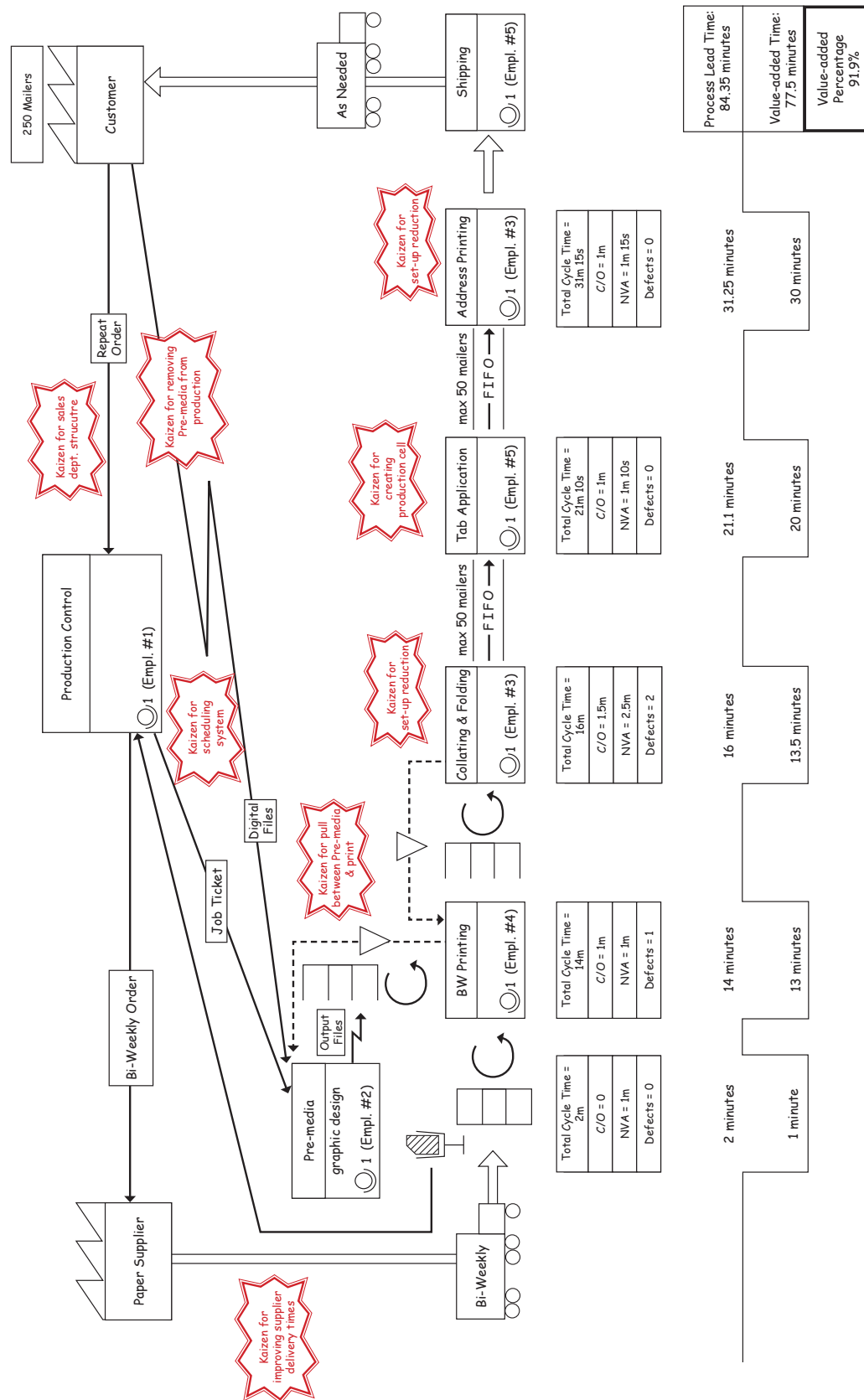


Figure 14. Future state value stream map for product family 2: digital black and white printing

pre-media whether there was downstream demand or not. In the new, ideal value stream, files would be released to the CTP machine by scheduling when pull was initiated downstream in finishing. The CTP supermarket can hold a designated number of plates ready for the press and be replenished when one is withdrawn. This will help eliminate cases of plates being misplaced or damaged while being shuffled around before use.

Pull within the system is controlled by kanban signals originating from the first finishing step, in this case padding. Padding is a uniquely time consuming process because it involves applying glue to the side of a paper stack then letting it dry for 30-40 minutes. The drying time is not really optional, but also is not value-added. It is not reasonable to pad one page at a time. So, the researcher proposes the delivery employee take stacks of about 250 pages as they come off the press and apply the glue while the next 250 are printed. This will allow the padding process to begin sooner than if the padding was done when all 2,000 sheets were finished printing. It also allows the next steps to begin as soon as the very first 250-page stack is dry. A Kaizen event focused on improving this step could further innovate on to reduce cycle time in another way. After padding the material moves to a two-person production cell combining the perforating, numbering and binding operations.

Estimates for the improved cycle times put the value-added percentage for this ideal value stream at 65% or more.

Future State Map. Like the previous two future state maps, pre-media remains a part of the production line, however it is combined with the CTP process to form a production cell. Currently, plates wait for the press operator to review, approve and “print” the plates once they are prepared by the graphic designer. The production cell would eliminate this by having the graphic designer cross-trained to know what requirements the pressman is checking for.

Padding is still the first finishing step and initiates the stream’s pull, but no does not feed into a production cell. The creation of a production cell is likely to require a Kaizen

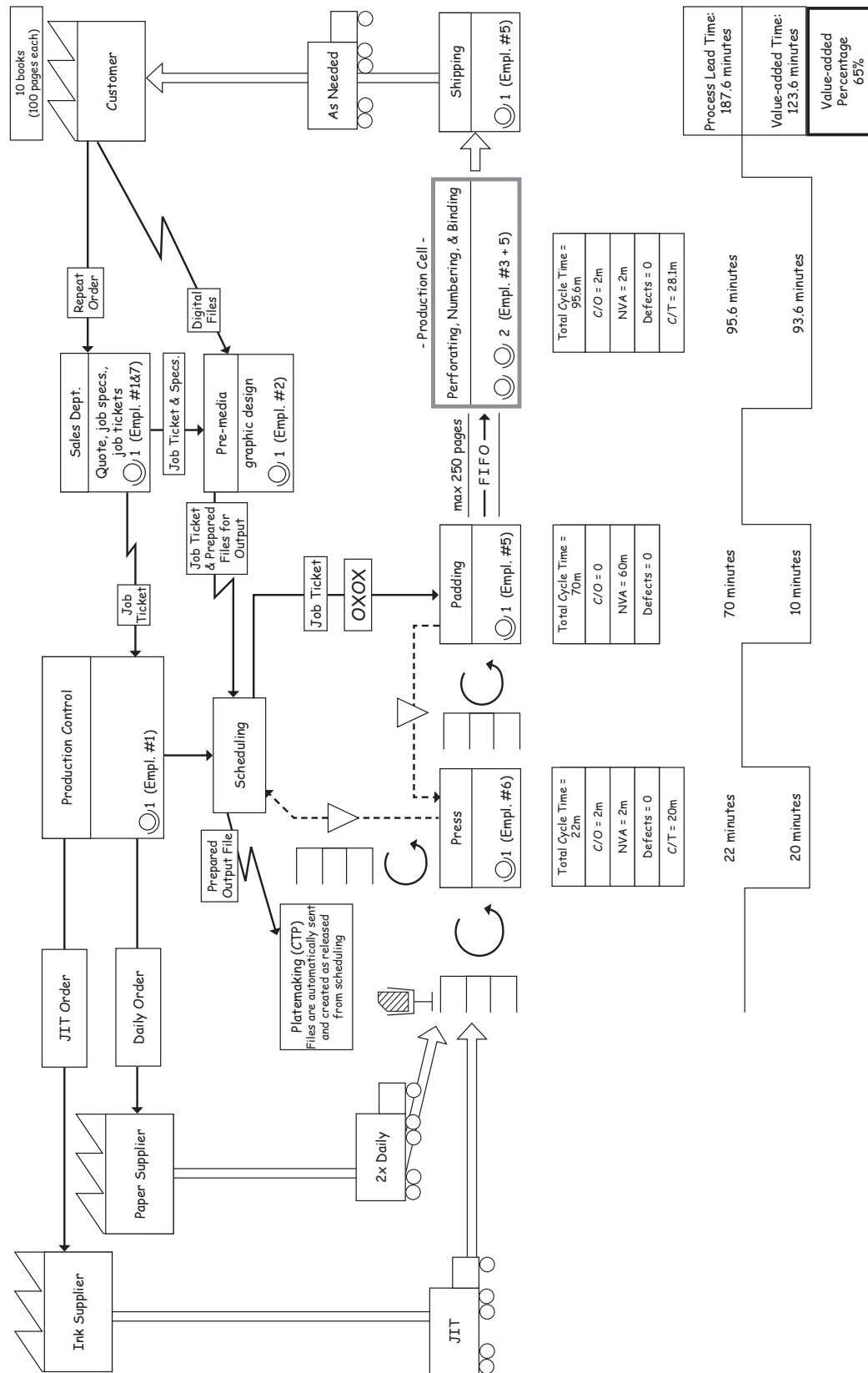


Figure 15. Ideal state value stream map for product family 3: offset press

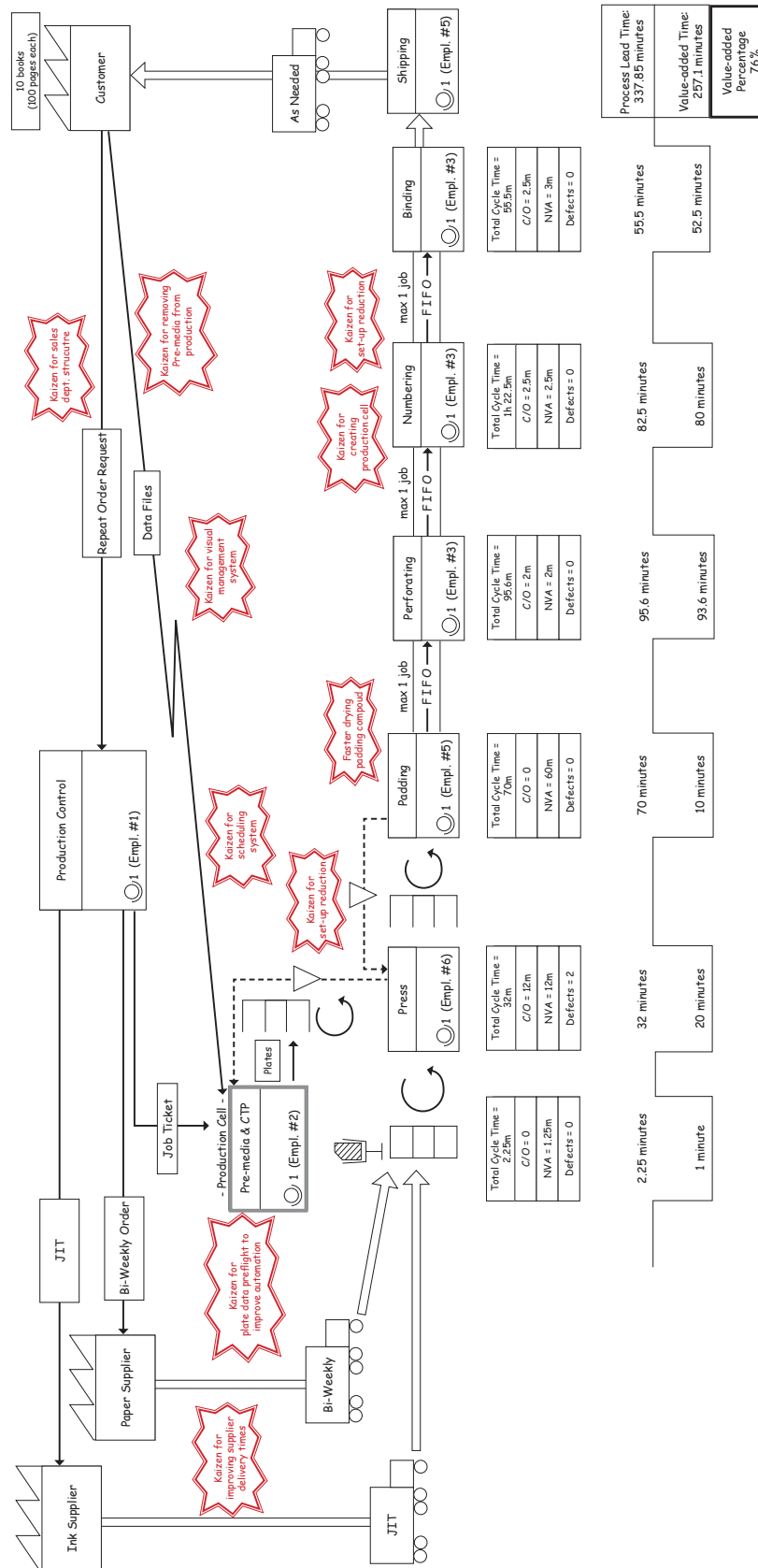


Figure 16. Future state value stream map for product family 3: offset press

event that may not be reasonable to expect within six months. Instead, the stream maintains continuous flow with FIFO lines to complete the required finishing steps. Kaizen bursts for the map also focus on the innovating the padding process, press setup reduction, and a kaizen for an automated preflight system to check plates as they are released to the CTP machine.

Implications of Research

The current value stream of Small Printer was represented and documented in a series of three product family specific maps. Each map illustrated the workflow using different printing methods with various states of finishing. Applying the concepts presented on Lean manufacturing revealed several sources of waste within the system that when targeted, would yield the greatest benefit. These areas are company culture, organization, pre-media and finishing bottlenecks, process scheduling, communication flow and inflated inventory. Ideal and future state maps were created illustrating how each value stream would function if Lean tools such as 5S, Kaizen events, setup reduction, total productive maintenance, and flow were implemented as part of an overall Lean initiative. The results show huge potential for Small Printer to reduce lead-time, increase value-added time, and improve conditions and morale for employees. Recommendations were given for addressing each of the key problem areas. The changes propose methods for restructuring and improving the existing system using the existing resources.

Limitations of the study

The duration and depth of this study was limited by the time and access the researcher had to obtain information about the shop. The researcher was limited to short periods over the course of observation, so as not to interfere with the shop's top clients who come in regularly. It became evident during initial data collection that obtaining meaningful data on OEE of various machines and precise, per piece process data would require a more in-depth study with longer-term access to the production floor.

Implications for the field

Applying Lean manufacturing principles to a small print shop that fulfills custom orders with very few employees can seem daunting, if not impossible to shop owners who are set in traditional methods. The theoretical framework provided in the literature review is oriented toward helping small- and medium-sized printers understand Lean as it applies to their field. The results and recommendations offer an introduction to value stream mapping and an in-depth example of a Lean plan to help printers become comfortable with applying Lean to their own organizations. This research could act as a springboard for future research and possibly future implementation of a Lean plan by Small Printer or another interested company.

To facilitate use of this study by the industry, the researcher plans to make it available to the National Association for Printing Leadership (NAPL), the Printing Industries of America (PIA), and the authors of WhatTheyThink.com. The researcher hopes this case study will help generate interest in the feasibility of Lean for small printers and encourage shop owners to rethink how they respond to the challenges the industry will face in the future.

Opportunities for future research

Future research could examine other small print shops to gather statistical data for a more in-depth mathematical analysis of the value stream and individual performance metrics. It would also be a valuable topic of study to observe and document a small print shop's actual process of implementing Lean changes, including the steps and struggles endured over an extended period.

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Appendices

Appendix A

How to Create and Read a Value Stream Map

Before a company can possibly know what changes to make it will need to know what the current state of the shop looks like. Value stream mapping is a visual tool or language, which can quickly allow the sharing of information about individual processes, information flow, and the stream as a whole. It is important to remain consistent in the symbols used when mapping so the information can be read and understood by others in the organization. The most commonly used icons are explained in Figure 17.

Mapping always starts with the customer's requirements and is designated with the factory icon to indicate an outside source. A data box should be placed adjacent to the icon with the customer's requirements written in short format. The customer icon is always placed in the upper right corner of the map and is the starting point for the VSM. Keep in mind that the customer is not always the end user of a product. Although most of the products produced by Small Printer go directly to the end customer, for many companies the customer is another factory or assembly plant.

The factory icon is also used to designate other outside sources by placing labeled icons in the upper left corner of the map. This includes any suppliers to the value stream—in the case of Small Printer, the suppliers are the paper and ink companies.

The company's "process control" is noted at the top of the map using a process box between the supplier and the customer. Every company has some version of production control, which is responsible for receiving customer orders, placing orders to suppliers and coordinating the production efforts of the shop floor. For Small Printer, this is the owner and sales department.

Value Stream Mapping Icons

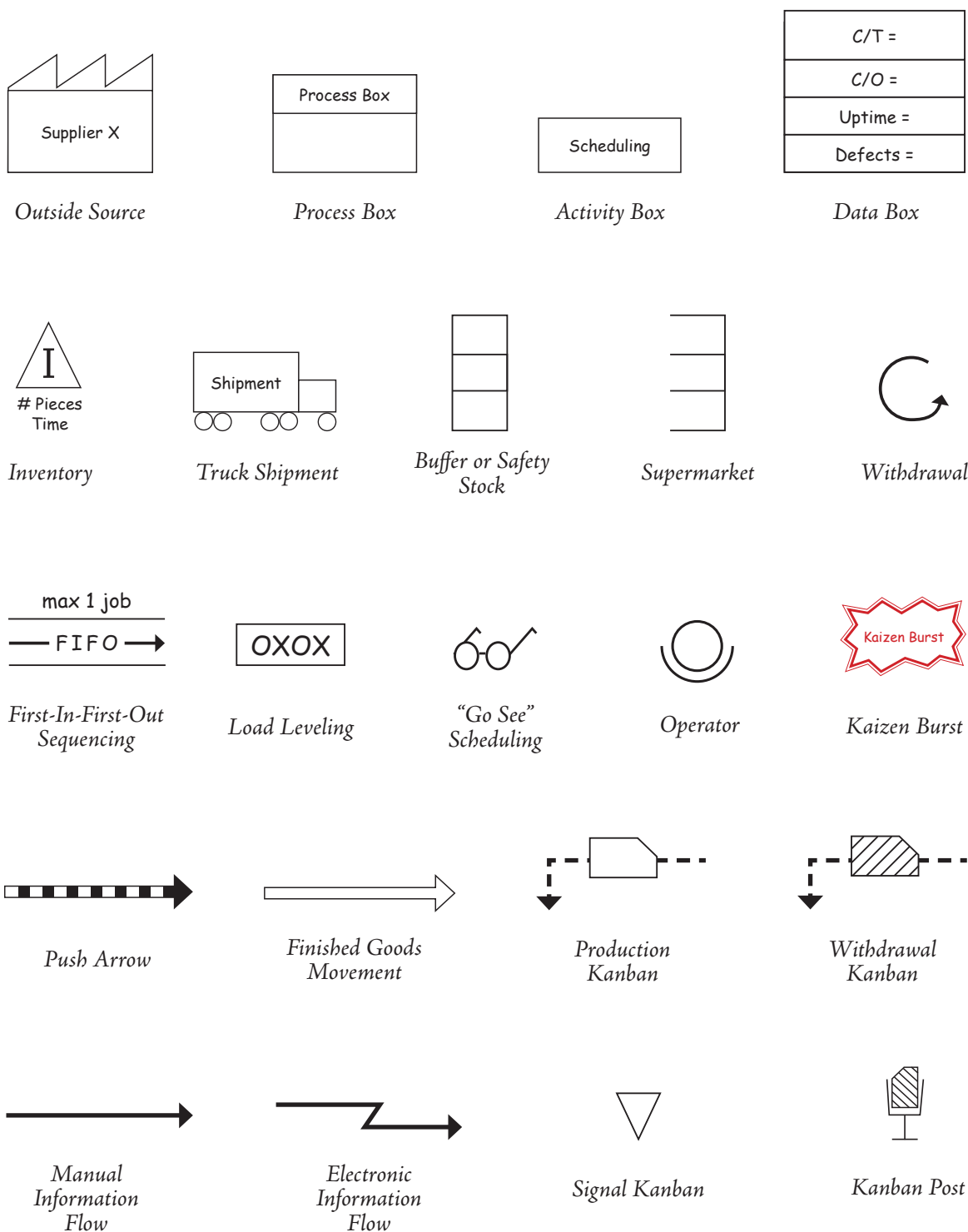


Figure 17. Common icons used in current and ideal state value stream mapping.

The next step is to walk the production line and document the basic processes with the process box. Drawing a box for every tiny step the production manager makes while cutting a stack of cards would result in process box for each cut. This micro mapping would clutter the map with unnecessary data and make it unusable. Instead, this box is used to indicate a step in production where the materials are flowing. If the cards being cut by the production manager are picked up, cut multiple times, and completed without any break or pause in the process, then the materials are considered to be flowing. A single process box can also be used when more than one operation is performed on the materials, such as on an assembly line, where the materials are moving continuously—even if there is a small amount of inventory accumulating between steps (Rother & Shook, 2009). In contrast, two separate process boxes would be used when complete batches of work-in-progress inventory stagnates or waits between steps.

Process boxes are drawn from left to right in the order that they are performed. The processes can branch if needed to show simultaneous steps within the value stream. A data box should be drawn below each process to document relevant information for later decision-making. Information that is usually collected includes cycle time, uptime, number of operators, defect rate, and changeover time. For more detailed explanation of the various types of process data, see Chapter 2.

At this point all the major processes should exist between the suppliers and the customer. Now it is time to document what happens between each step. This is where value stream mapping breaks away from being simply a workflow diagram. Value streams document what happens while the jobs or materials are waiting to be processed and the flow is stopped. Whenever material accumulates between processes, it is called work-in-progress (WIP) and is diagramed as a triangle with an “I” in the center. Below the triangle, write how much inventory is waiting and for how long.

Information flow is a critical component of a functioning shop and is also a key aspect of the VSM. Manual information flow is shown with a thin, simple, straight line and arrow.

When information flows electronically, it is shown with a thin lightning bolt arrow. These arrows should be labeled to indicate what type of information is being sent.

Wide, open arrows indicate the movement of finished goods and are used to show supplier deliveries and the shipment of goods to the customer. A truck icon indicates shipment and should be labeled with the frequency of deliveries.

The final step to complete the map is to identify where materials are being “pushed” or “pulled” through the system. Materials are considered pushed when an upstream process produces its product or performs its operation regardless of input that the downstream processes are ready to receive the output (Cooper, Keif & Macro Jr., 2007). When each process is isolated from the others, such as the three printing departments at Small Printer, they tend to perform based on their own schedules even if the downstream finishing processes are completely backlogged with unfinished work. Push is illustrated on the map by a wide striped arrow.

Lean production is centered on the concept of “pull” where materials are not produced upstream until the downstream processes indicate need. There is no pull icon. Instead, various Lean methods such as FIFO lanes, supermarkets, and manufacturing cells are used to move materials from one process to the next. These concepts are explained in Chapter 2.

A timeline is drawn beneath the completed map summarizing the data from the process boxes and WIP inventories. Typically, the WIP times used along the timeline are calculated by dividing the amount of wait time by the number of pieces waiting. However, for Small Printer, the units being documented were entire jobs, so the WIP for a stack of cards was considered one piece. The timeline also shows the process cycle times and value creating times below the corresponding process boxes. The values across the timeline are added together to generate production lead-time and total value-added time on the bottom right of the map.

Appendix B

Data Collection Tables

The following tables contain the information gathered during observation of Small Printer's value stream. The data was collected in open format worksheets to allow accurate capturing of actions as they happen, rather than based on the researcher's assumptions of the workflow. This data is summed up in process data tables in Appendix C. Although only three value streams were discussed in the results section, the researcher documented and created value stream maps for five jobs. The value stream maps for these jobs can be found in Appendix D.

Product Family: Digital Color Printing
Job Type: Menu Cards
Quantity:
40 Menus

Print Specifications:
Color, Simplex

Finishing Specifications:
Cut to 4"x11"

Activity	Employee	Method	Time Spent	Issues / Comments
Repeat customer calls to discuss job with designer (prefers to speak with designer instead of service rep)	2	Phone conversation - customer insist on talking directly to the designer	5m	No quote is given. Details are discussed and customer will follow up in email. Repeat customer who has repeat business - billed monthly.
Customer emails designer with job specifications & designer prints email	2	Email is printed	30s	
Designer walks printed email to front desk to be written up as job ticket	2	Walking email to desk	5s	
Job waits for a time when service employee is free to call customer and write up ticket			24h	Backlog of jobs at front desk waiting to be written up
Service employee inputs data into invoice system and prints job ticket.	1	Invoice software	5m	
Job ticket is printed and given back to designer	1	Walked to designer	10s	
Job ticket waits for time when designer is free to work on it			6h	
Designer lays out job per instructions from customer	2	InDesign	15m	
PROOF #1: PDF proof is sent to customer	2	Email	1m 30s	This is the act of creating and sending the proof
PROOF #1: Waiting for customer response	2		1h	
PROOF #1: Receive changes from customer	2	Email	1m	
PROOF #1: Make changes to design/layout	2	InDesign	15m	
PROOF #2: PDF proof is sent to customer	2	Email	45s	This is the act of creating and sending the proof
PROOF #2: Waiting for customer response	2		20h	
PDF proof is approved for print	2	Email	1m	
Design is impositioned for print	2	InDesign	10m	File is large and slows computer
Walk to paper storage	2	Walking	10s	
Locate and obtain proper paper	2	Walking/looking	5m	Paper storage is disorganized. The wrong paper size is used in an attempt to use up old stock
Insert paper into bypass tray	2	Manual	10s	
Set print setting on printer	2	Manual	15s	
Set settings on computer	2		15s	No predefined settings for standard job types
Print 60 copies	2	Digital printer	3m	
Printed pages are carried over to cutting station	2	Walking	10s	
WIP - waiting for cutter			40m	
Cards measured for cutting	3	Measuring tool	10s	Cutter is currently partially broken - requiring manual measuring and placement in machine
Cut 1	3	Cutter	15s	
Cut 2	3	Cutter	15s	
Cut 3	3	Cutter	15s	
Cut 4	3	Cutter	15s	The use of paper that was too small resulted in 20 of the cards being unusable. Fortunately, 60 cards were printed, so the correct number (40) was left.
Job is boxed for customer	3	Manually boxed, and labeled	1m30s	
Finished job is walked over to front desk pick-up area	3	Walking	5s	
Finished job waits for the service employee to call customer for pickup			18h	
Service employee calls customer to inform of job completion	1	Phone	3m	Customer is called first thing the following morning

Table 5. Data collection worksheet for the first job in product family one. The product produced was color, digitally printed menu cards for a local restaurant. The accompanying value stream maps for this job are discussed in Chapters 5 and 6.

Product Family: Digital Color Printing
Job Type: Wedding Invitations & Thank You Cards

Quantity:
125 each

Print Specifications:
Color, Duplex

Finishing Specifications:
Cutting (Invitations 5x14 , Cards 6x5), scoring, perforating

Activity	Employee	Method	Time Spent	Issues / Comments
Customer walks in to discuss job and quote	1	Discussion	20m	No written pricing for unique order types. Order details are written on a notepad to be either entered into the shop's invoice system or directly given to employees in place of a work order. These notes are also the extent of the job planning.
Creation of job box	1	Hand written notes (no formal ticket created)	1m	Company uses shallow boxes to hold all paperwork pertaining to specific jobs as they move through production. If a formal job ticket was made, it would also travel in this box.
Job is given to designer (design/premedia department)	1	Walking box to desk	10s	No electronic scheduling system in use. Sole reliance on written instructions.
Job is verbally explained to designer	1 + 2	Verbal discussion	5m 30s	Explanation of notes needed
Job ticket waits for time when designer is free to work on it			3h	
Layout of invitation and thank you cards	2	Indesign + Scanner	30m	
PROOF #1: PDF proof is sent to customer	2	Email	1:30m	This is the act of creating and sending the proof
PROOF #1: Waiting for customer response	2		24h	
PROOF #1: Receive changes from customer	2	Email	3m	
PROOF #1: Make changes to design/layout	2	InDesign	10m	
PROOF #2: PDF proof is sent to customer	2	Email	45s	This is the act of creating and sending the proof
PROOF #2: Waiting for customer response	2		46h	
PROOF #2: Receive changes from customer	2	Email	1m	
PROOF #2: Make changes to design/layout	2	InDesign	10m	
PROOF #3: PDF proof is sent to customer	2	Email	45s	This is the act of creating and sending the proof
PROOF #3: Waiting for customer response	2		2h	
PROOF #3: Receive changes from customer	2	Email	1m	
PROOF #3: Make changes to design/layout	2	InDesign	10m	
PROOF #4: PDF proof is sent to customer	2	Email	45s	This is the act of creating and sending the proof
Waiting for customer response	2		35h	
PDF proof is approved for print	2	Email	1m	
Design is impositioned for print	2	InDesign	3m	
Walk to paper storage	2	Walking	10s	
Locate and obtain proper paper	2	Walking/looking	5m	
Insert paper into bypass tray	2	manual	10s	
Set print setting on printer	2	manual	15s	
Set settings on computer	2		15s	No predefined settings for standard job types
Print 125 copies - front of invitation	2	digital printer	9m29s	
Print 125 copies - back of invitation	2	digital printer	8m18s	Manually duplexed due to paper weight and alignment requirement
Printed pages are carried over to cutting station	2	walking	10s	
WIP - waiting for cutter			24m	
Cutter operator requires explanation of job notes (unclear)	3	Verbal discussion with employee #1	4m	Written instructions are incomplete and unclear requiring clarification at each stage.
Cards measured for cutting	3	measuring tool	10s	Cutter is currently partially broken - requiring manual measuring and placement in machine
Cut 1	3	Cutter	17s	
Cut 2	3	Cutter	13s	
Cut 3	3	Cutter	12s	

Continued on next page.

Cut 4	3	Cutter	20s	
WIP - waiting to be scored next day			15h	
Set up scoring machine for thank you cards	3	Scoring machine	1m	
Actual act of scoring thank you cards	3	Scoring machine	30s	125 cards in 30 sec
Scoring machine is set up for invitations	3	Scoring machine	1m 30s	
Invitations are scored	3	Scoring machine	30s	
Set up of perforating machine	3	Perforating machine	5m	
Perforating invitations	3	Perforating machine	5m	
Job is boxed for customer	3	manually boxed, and labeled	1m30s	
Finished job is walked over to front desk pick-up area	3	walking	5s	
Finished job waits for the service employee to call customer for pickup			30m	
Service employee calls customer to inform of job completion	1	phone	3m	

Table 6. Second data collection worksheet for product family one. The product produced was color, digitally printed wedding invitations and thank you cards. The accompanying value stream maps for this job are shown in Appendix D.

Product Family: Digital Black and White Printing		Job Type: Company Mailers
Quantity: 250 Mailers	Print Specifications: BW, Duplex, (1) 11x17 + (1) 8.5x11 per mailer	Finishing Specifications: 2 folds, 2 tab closures, address printing

Activity	Employee	Method	Time Spent	Issues / Comments
Customer emails designer with job specifications	2	Email is printed	30s	
Designer walks printed email to front desk to be written up as job ticket	2	Walking email to desk	5s	No electronic scheduling system in use. Sole reliance on written instructions.
Service employee inputs data into invoice system and prints job ticket.	1	Invoice software	24h	Backlog of jobs at front desk waiting to be written up
Job ticket is printed and given back to designer	1	Walked to designer	10s	
Designer creates PDF from supplied Word Document	2	Microsoft Word	1m	
PDF file is placed on the server for the black and white copier	2	Servers	30s	
Designer walks job ticket over to black and white printing department	2	Walking	10s	
Designer tells BW dept employee about the job - very brief	2	Verbally	30s	
Data waits to be printed			60m	
BW Dept. Employee retrieves file from server	4	Servers	10s	
BW dept sets up printer settings for first page to be printed	4	Konica BW printer	1m	
First page is printed	4	Konica BW printer	8m	11x17, 2 sided, 250 copies
BW dept sends sets up printer settings for second page to be printed	4	Konica BW printer	1m	
Second page is printed	4	Konica BW printer	5m	8.5 x 11, 2 sided, 250 copies
finished prints are stacked and wait for production employee to come fold them (WIP).			6h	
Production employee sets up collating and folding machine	3		2m	
Machine collates and folds	3		6m	Pages are collated and the first fold completed

Continued on next page.

Machine is set up for second fold	3		1m	
Employee hand feeds documents for second for manually	3		8m	The machine requires each packet be inserted individually
Folded mailers are gathered at end of machine and brought to mailing area	3		40s	
Mailers are transported to next machine station	3		20s	
Tab machine is set up to place first tab closing mailers	3		2m	Post office requires 2 tabs holding mailer shut
1st tab is applied to mailers	3		10m	
2nd tab is applied to mailers	3		10m	
Mailers are stored overnight (WIP)			15hr	
File and inkjet printer are prepared for variable data printing (addresses)	3		2m	Short set up time due to repeat job
Inkjet prints addresses	3		30m	
Finished mailers are assembled into trays to be taken to the post office	3		1m 30s	
Finished mailers are brought to delivery area	3	Walking	10s	
Finished mailers wait for delivery			30m	
Delivery employee delivers mailers to local post office	5	Driving	15m	Mailers are taken to post office

Table 7. Data collection worksheet for product family two. The product produced was black and white, digitally printed company mailers. The accompanying value stream maps for this job are discussed in Chapters 5 and 6.

Product Family: Offset Press			Job Type: Carbonless Forms	
Quantity: 2,000 impressions, 10 books of carbonless forms		Print Specifications: 1-color	Finishing Specifications: Padding, perforating, numbering, binding	
Activity	Employee	Method	Time Spent	Issues / Comments
Repeat customer calls to request job	1	Phone Conversation	15m	This is a repeat job that requires no design work. The same file used last time will be used again to make the plates
Service employee inputs data into invoice system and prints job ticket.	1	Invoice software	10m	This job was a rush order, so it went to the front of the line in scheduling
Job ticket is given to designer	1	Walked to designer	10s	
Job ticket waits for time when designer is free to work on it			3h	
Designer converts Word Document to PDF for output	2	Microsoft Word	1m	File is supplied via email from client
Designer sends plates to print on CTP machine	2	CTP	10s	
Plate data waits to be printed (WIP)			2h	
Press operator reviews plates prior to them being printed to check for mistakes	3		1m	
Plates are printed	3		1m	
Plates wait with job ticket until press is ready for job WIP			1hr	
Prep inks - skim excess	3		1m	
Apply ink to rollers	3		15s	
Hang plates	3		1m	Machine automates some of this
Priming plates	3		3m30s	
Changing sheet size settings on press (manually)	3		1m	
Adjusting for paper weight	3		3m	

Continued on next page.

Adjust registration and ink density using junk paper	3		2m	
Printing final forms	3		20m	2000 impressions. Press jammed a couple times and needed to be stopped. This is caused by super light paper that has to be fed long side first. Press must be monitored and operator can't really leave press area. 6500 impressions per hour average on simple stuff, 10,000 per hour capacity
Single color wash-up	3		12m	
Finished forms are walked over to bindery department	3		10s	
Forms become work in progress while drying and waiting to be padded	3		20h	Forms need to dry overnight
Padding - coat 1	5		5m	Pressure is applied to top of stack, then padding compound is applied with a brush to the side of the stack
Padding - Dry time WIP	5		40m	
Padding - coat 2	5		5m	Pressure is applied to top of stack, then padding compound is applied with a brush to the side of the stack
Padding - Dry time WIP	5		40m	
Transport to perforating machine station	5		20s	
Forms wait to be perforated			30m	
Perforating - machine set up	3		5m	3 perforations across page to create tickets
Perforating - Perf 1	3		30m	
Perforating - machine set up	3		1m	3 perforations across page to create tickets
Perforating - Perf 2	3		30m	
Perforating - machine set up	3		1m	3 perforations across page to create tickets
Perforating - Perf 3	3		30m	
Transport to numbering machine station	3		20s	
Numbering - machine set up	3		5m	File is already in place from previous jobs, so set-up time is reduced
Numbering - machine run time	3		1h20m	
Transport to binding machine station	3		20s	
Locating paper stock for covers	3		5m	
Set up binding machine	3		2m	Only 10 sheets - forms will be bound into 10 books
Binding - scoring cover stock	3		5m	Only 10 sheets - forms will be bound into 10 books
Binding - Act of binding	3		50m	5m per book - wrap around cover, spiral bound
Finished books are boxed up and labeled	3		2m	
Finished books are brought to delivery area	3	Walking	10s	
Finished books wait for delivery			15h	Books are delivered first thing the following day
Delivery employee delivers books to local client	5	Driving	15m	

Table 8. Data collection worksheet for product family three. The product produced was 1-color, offset printed carbonless forms. The accompanying value stream maps for this job are discussed in Chapters 5 and 6.

Product Family: Offset Press
Job Type: Business Cards

Quantity:
250 cards, 25 sheets

Print Specifications:
1-color 8.5"x11"

Finishing Specifications:
Cut to 3.5"x2"

Activity	Employee	Method	Time Spent	Issues / Comments
Repeat customer emails designer to discuss job & to give specifications	2	Email conversation	3m	No quote is given. Repeat customer who has repeat business - billed monthly.
Designer walks printed email to front desk to be written up as job ticket	2	Walking email to desk	5s	
Job waits for a time when service employee is free to call customer and write up ticket			24h	Backlog of jobs at front desk waiting to be written up
Service employee calls client to discuss details and quote	1	Phone conversation	10m	Standard quote is given for cards - same price as all other cards produced for this company
Service employee inputs data into invoice system and prints job ticket.	1	Invoice software	5m	
Job ticket is printed and given back to designer	1	Walked to designer	10s	No formal scheduling system in use
Job ticket waits for time when designer is free to work on it			2h	
Designer lays out job per instructions from customer	2	InDesign	15m	Repeat job - layout involves inserting and formatting new information into similar template
Designer impositions cards for printing	2	InDesign	2m	
Designer sends plates to print on CTP machine	2		10s	
Plate data waits for press operator to verify information is correctly laid out			16h	
Press operator reviews plates prior to them being printed to check for mistakes	3		1m	
Plates are printed	3		1m	
Plate wait in job box until the press operator is ready to print this job			6hr	
Prep inks - skim excess	3		2m	
Apply ink to rollers	3		45s	
Hang plates	3		2m	
Priming plates	3		4m	
Changing sheet size settings on press (manually)	3		1m	
Adjust paper pickup in machine for heavy paper	3		2m	
Adjust ink density	3		2m	
Printing final cards	3		4m	Cards are printed on "master stock" that has been preprinted with logo in spot colors to reduce time spent each press run
Single color wash up	3		12m	
Cards are brought to cutting area	3	Walking	10s	
Cards must dry overnight before cutting (WIP)			16h	
Cards are cut to size	3	9 cuts on stack cutter	4m30s	No bleed
Job is boxed for customer	3	Manually boxed, and labeled	1m	
Finished cards are brought to delivery area	3	Walking	10s	
Finished cards wait for delivery			13h	Cards are delivered first thing the following day
Delivery employee delivers cards to local client	5	Driving	10m	

Table 9. Second data collection worksheet for product family three. The product produced was 1-color, offset printed business cards. The accompanying value stream maps for this job are shown in Appendix D.

Appendix C

Process Data Tables

The data from the open format worksheets is summed up in the following process data tables, which frame the results in a useful way for value stream mapping.

Product Family: Digital Color Printing		Job Type: Menu Cards		
Quantity: 40 Menus	Print Specifications: Color, Simplex	Finishing Specifications: Cut to 4"x11"		
All Times in Minutes				
Process Data	Premedia	Press	Postpress	WIP
Changeover Time	0	0.5	0	
Total Cycle Time	1302.25	9	2.75	
Defects	0	0	40 menus	
Number of People	1	1	1	
Batch Size		80 menus	80 menus	
VA Time	37	3	1	
NVA Time	1265.25	6	1.75	1120

Table 10. Process data for the first job in product family one. The product produced was color, digitally printed menu cards for a local restaurant. The accompanying value stream maps for this job are discussed in Chapters 5 and 6.

Product Family: Digital Color Printing		Job Type: Wedding Invitations & Thank You Cards		
Quantity: 125 each	Print Specifications: Color, Duplex	Finishing Specifications: Cutting (Invitations 5x14 , Cards 6x5), scoring, perforating		
All Times in Minutes				
Process Data	Premedia	Press	Postpress	WIP
Changeover Time	0	0.5	7	
Total Cycle Time	6492.3	23.8	20.3	
Defects		4	0	
Number of People	1	1	1	
Batch Size	250	250	250	
VA Time	59.2	17.8	7	
NVA Time	6433.1	6	13.3	954

Table 11. Process data for the second job in product family one. The product produced was color, digitally printed wedding invitations and thank you cards. The accompanying value stream maps for this job are shown in Appendix D.

Product Family: Digital Black and White Printing		Job Type: Company Mailers		
Quantity: 250 Mailers	Print Specifications: BW, Duplex, (1) 11x17 + (1) 8.5x11 per mailer	Finishing Specifications: 2 folds, 2 tab closures, address printing		
All Times in Minutes				
Process Data	Premedia	Press	Postpress	WIP
Changeover Time	0	2	7	
Total Cycle Time	5.75	15.17	73.67	
Defects	0	1	2	
Number of People	1	1	1	
Batch Size		500 pages	250 mailers	
VA Time	1	13	64	0
NVA Time	4.75	2.17	9.67	1350

Table 12. Process data for product family two. The product produced was black and white, digitally printed company mailers. The accompanying value stream maps for this job are discussed in Chapters 5 and 6.

Product Family: Offset Press		Job Type: Carbonless Forms		
Quantity: 2,000 impressions, 10 books of carbonless		Print Specifications: 1-color	Finishing Specifications: Padding, perforating, numbering, binding	
All Times in Minutes				
Process Data	Premedia	Press	Postpress	WIP
Changeover Time	0	23.75	17	
Total Cycle Time	3.2	43.9	337.1	
Defects	0	5 forms (10 sheets)	2 forms	
Number of People	1	1	1	
Batch Size		2,000 sheets	1,000 forms, 10 books	
VA Time	1	20	230	
NVA Time	2.2	23.9	107.1	2310

Table 13. Process data for the first job in product family three. The product produced was 1-color, offset printed carbonless forms. The accompanying value stream maps for this job are discussed in Chapters 5 and 6.

Product Family: Offset Press		Job Type: Business Cards		
Quantity:	Print Specifications:	Finishing Specifications:		
250 cards, 25 sheets	1-color 8.5"x11"	Cut to 3.5"x2"		
All Times in Minutes				
Process Data	Premedia	Press	Postpress	WIP
Changeover Time	0	25.75	0	
Total Cycle Time	19.2	29.9	5.67	
Defects	0	10 sheets	0	
Number of People	1	1	1	
Batch Size		25 sheets	25 Sheets, 250 cards	
VA Time	15	4	4.5	
NVA Time	4.2	25.9	1.17	3060

Table 14. Process data for the second job in product family three. The product produced was 1-color, offset printed business cards. The accompanying value stream maps for this job are shown in Appendix D.

Appendix D

Additional Value Stream Maps

The following two value stream maps were created, but not directly discussed in the research results. Each represents the current state for an additional job in product families one and three; digital color printing and offset press.

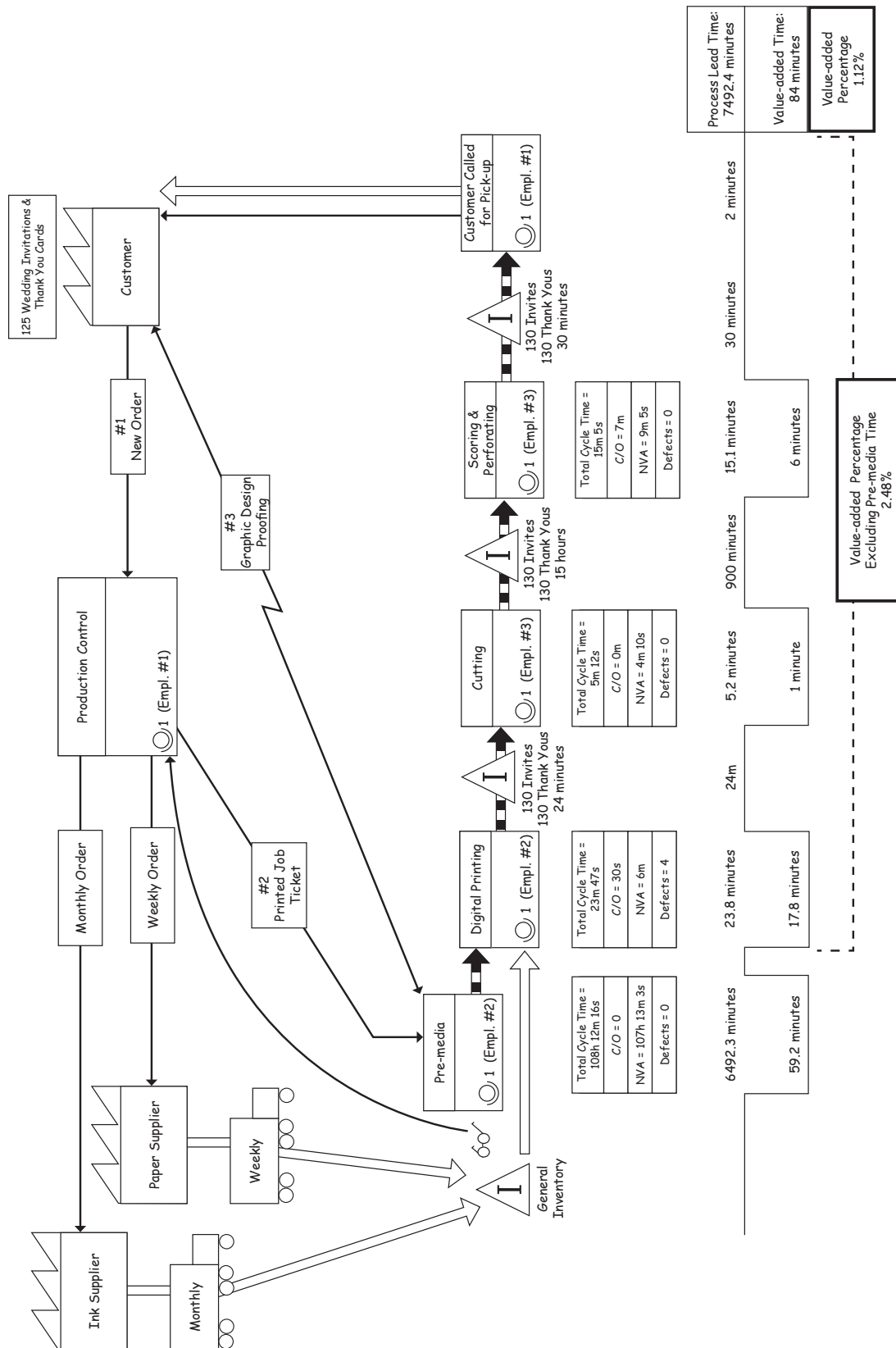


Figure 18. Current state value stream map for additional job in product family 1: digital color printing.

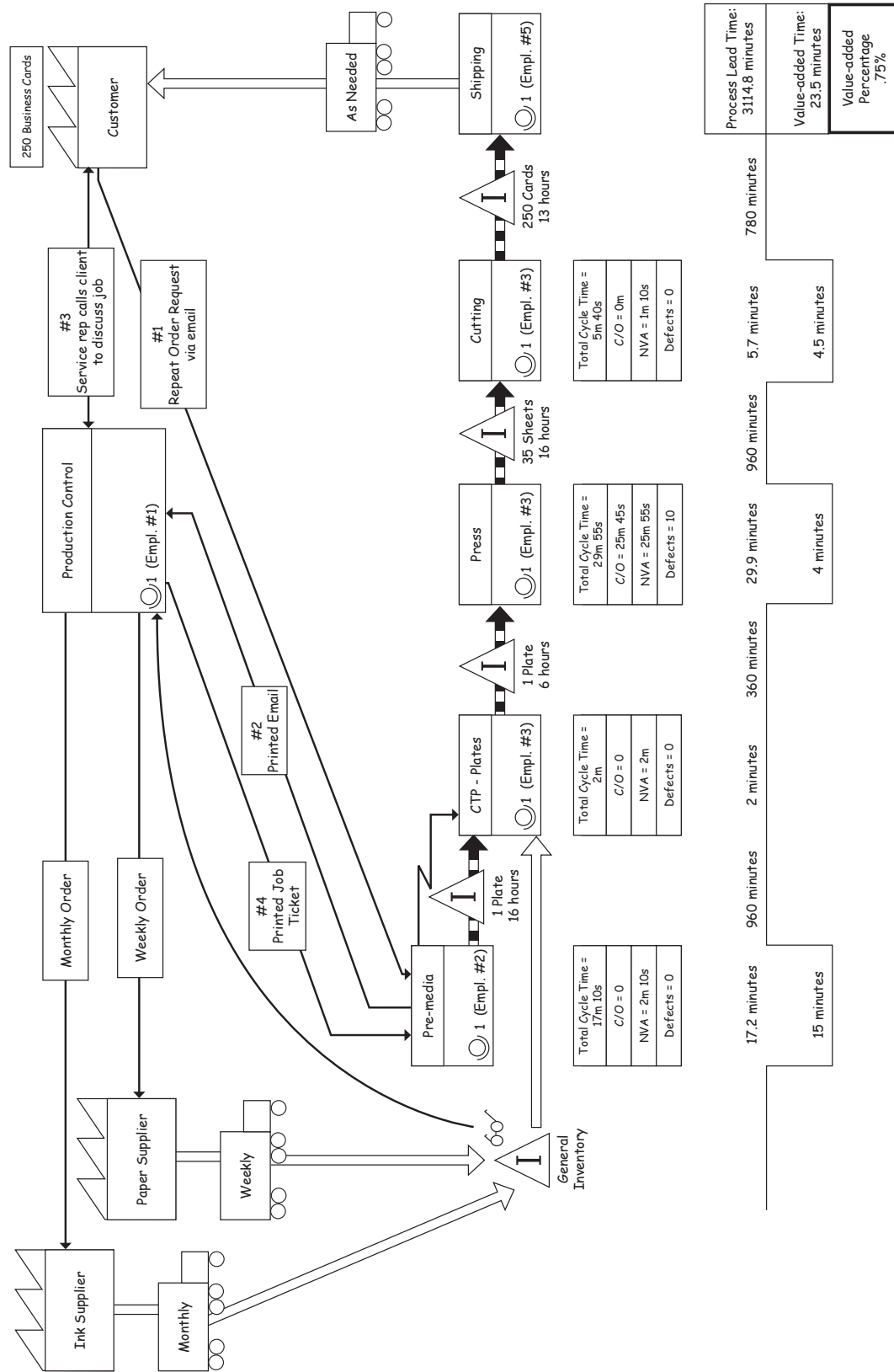


Figure 19. Current state value stream map for additional job in product family 3: offset press